Engineering Library

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See Advertisement page 57, May 1. 2402

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See Full Page Advt., page 65, April 24.

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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See Advert., page 62, April 24. 2195

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(Faculty of Technology.)

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The Governing Body announce the offer of a Scholarship of the value of £50 per annum for three years, tenable in one of the University Engineering Courses in the College of Technology.

Forms of nomination and all information may be obtained on application to the Registrar of the College.

Applications must be received on or before 15th June. H 977

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Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2676

TENDERS.

COUNTY BOROUGH OF PRESTON.

ELECTRICITY DEPARTMENT.

The Electricity Committee invites

Tenders for the Purchase and

REMOVAL of STEAM and ELECTRICAL PLANT, including A.C. and D.C. Turbo Generators, Boilers, Switchgear, &c., installed at the Crown Street Power Station, Preston.

For further particulars apply to:—
The Borough Electrical Engineer,
118, Fishergate,
Preston. H 958

CITY OF NOTTINGHAM.

WATER DEPARTMENT.

TEST PUMPING, BURTON JOYCE.

The Water Committee invite

Tenders from Competent

Contractors for PROVIDING the necessary PLANT for testing the yield of water from three boreholes at the Burton Joyce Pumping Station, situate in Shaftesbury Avenue, Burton Joyce, Notts.

General Conditions, Specification, Schedule and Form of Tender may be obtained from Mr. F. W. DAVIES, Engineer and General Manager, Water Offices, Castle Boulevard, Nottingham, on payment of a deposit of £2 2s., which will be refunded on receipt of a *bona fide* Tender not afterwards withdrawn, and the return of all documents.

Tenders must be endorsed "Tender for Test Pumping at Burton Joyce," and reach the undersigned not later than the 25th day of May, 1925.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. J. BOARD, O.B.E.,
Town Clerk.

Guildhall,
Nottingham.
2nd May, 1925. H 952

TO BOREHOLE CONTRACTORS.

COUNTY BOROUGH OF BOLTON.

WATERWORKS DEPARTMENT.

SPRINGS WELL AND BROMILEY WELL.

Tenders are invited for the

SINKING BY BORING of the above-mentioned WELLS, each having a commencing diameter of not less than 24 in., and a terminating diameter of not less than 12 in. at a depth of 700 ft., and for the Construction of other Works connected therewith at Belmont, near Bolton.

The drawings, conditions of contract, specifications, schedules for prices, instructions to persons tendering, and forms of Tender, can be seen on application to MR. JOHN K. SWALES, M.Inst.C.E., Waterworks Engineer, 8a, George's Street, Bolton, after 11th May, 1925, and copies in respect of either or both of the Wells may be obtained on the deposit of Two Guineas, which will be returned to Tenderers who have submitted a *bona-fide* Tender and returned all the documents supplied.

Tenders, separate in respect of each Well, are to be submitted in accordance with the "Instructions to persons Tendering," above referred to, before 10 a.m., on the 25th May, 1925.

SAMUEL PARKER.
Town Clerk.

Town Hall,
Bolton.
4th May, 1925. H 957

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply

of:—

1. LOCOMOTIVE TANK ENGINES.
2. CARRIAGE UNDERFRAMES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked, "Tender for Locomotives," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 5th June, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £3 for each copy of Specification No. 1, and of 10s. for each copy of specification No. 2.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, of 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
6th May, 1925. H 999

CORPORATION OF GLASGOW.

TRAMWAYS DEPARTMENT.

Sub-station Plant for Sale.

The Tramways Department of the Corporation of Glasgow, are prepared to receive

Offers for the undernoted

PLANT, which can be seen at Coplawhill Sub-station, 522, Pollokshaws Road, Glasgow, S.S.

The Plant was supplied and installed in Paisley by the British Westinghouse Electrical Co. (now Metropolitan-Vickers Electrical Co.) in 1920, and passed to this Department from Paisley Burgh at the recent acquisition of the Paisley Tramways.

2 Rotary Converters, 500 Kw. Compound wound with compoles 6 phase, 6 pole, 50 periods=1000 Revs., 550/600 volts, 910,835 amps. (Serial Nos. 642191 and 642193), complete with Starting Motor, Three-phase Oil-immersed Transformers, Oil Break Switches, Starting Panels, and D.C. Panels.

Specifications of the Plant, Conditions of Sale and further particulars can be obtained on application to Mr. JAMES DALRYMPLE, General Manager, 46, Bath Street, Glasgow. Sealed Offers, marked outside "Tramways—Tender for Sub-station Plant for Sale," must be lodged with the Subscriber on or before Tuesday, 26th inst., at Ten a.m.

The highest or any offer may not be accepted.

J. LINDSAY,
Town Clerk.

City Chambers, Glasgow.
5th May, 1925. H 980

ADMINISTRATIVE COUNTY OF LONDON.

TWIN SCREW STEAMSHIP.

The LONDON COUNTY COUNCIL invites

Tenders for the Construction

and DELIVERY of a TWIN SCREW STEAMSHIP, about 260 ft. long by 43 ft. beam, with machinery, etc., for the conveyance of 1500 tons of sewage sludge from the Outfall Works at Crossness and Barking Creek to the North Sea.

Persons desiring to submit Tenders may obtain, on and after Monday, the 11th May, 1925, the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the vessel may be obtained on personal application, and the drawings, specification and other contract documents may be inspected at the Old County Hall before payment of the fee.

No Tender received after 4 p.m. on Monday the 8th June, 1925, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX, H 966
Clerk of the London County Council.

BIRMINGHAM UNION.

TO HEATING AND HOT WATER ENGINEERS.

The Guardians invite

Tenders for the Installation of

HEATING and HOT WATER SERVICES, etc., in the Nurses' Home extension to be provided at the Selly Oak Hospital, Birmingham, in accordance with specifications and plans prepared by Mr. Noel W. GREENWAY, B.Sc., Consulting Engineer, of Lloyds Bank Chambers, New Street, Birmingham.

Firms desiring to tender for this work must apply to me, the undersigned, in writing, and deposit the sum of Five guineas for specifications and plans. Cheques should be made payable to "The Treasurer, Birmingham Union."

The amount so deposited will be returned by the Guardians' cheque on receipt of a *bona fide* Tender sealed and endorsed "Heating and Hot Water Services, Selly Oak Hospital,' and forwarded so as to reach me not later than Ten a.m., on Monday, the 18th May, 1925.

The successful Tenderers will be required to give security for an amount to be fixed by the Guardians, to pay during the execution of the contract to the whole of the workpeople engaged on the work not less than the Trade Union or Standard rate of wages and to observe the hours and conditions of labour recognised by the Employers' and Workers' Associations.

They will also be required to enter into an agreement absolving the Guardians from any liability under all statutes and Common Law relating to compensation to workpeople.

As far as practicable, the general conditions adopted by the Guardians will be applied to the Contract.

A copy of such conditions may be inspected at these offices.

The Guardians do not bind themselves to accept the lowest or any Tender.

JAMES CURTIS,
Clerk to the Guardians.

Union Offices,
Edmund Street,
Birmingham.
1st May, 1925. H 944

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

Tenders for :—

1. AXLES for Railway Carriages and Wagons.
2. AXLE BOXES for Railway Carriages and Wagons.
3. WHEELS and AXLES for Railway Carriages and Wagons.
4. DRAGLINE EXCAVATORS.
5. OIL TANK WAGONS, Railway.

Tenders due on the 19th May, 1925, for Nos. 1 to 3, and on the 26th May, 1925, for Nos. 4 and 5.

Tender Forms obtainable from above. H 981

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 43, Copthall Avenue, London, E.C. 2, invite

Tenders for :—

		s.	d.
1.	Lamp Glasses, etc.	Fee 7	6
2.	Lamps and Fittings	,, 5	0
3.	Locomotive Boilers	,, 20	0
4.	Bright Drawn Mild Steel Bars (for use in Automatic Lathes, etc.) ...	,, 5	0
5.	Bright Brass Bars (for use in Automatic Lathes)...	,, 5	0
6.	Drawn or Extruded Brass Bars (Brazing quality)	,, 2	6
7.	Mild Steel Bars (for Loco. and Carr. and Wagon Parts)	,, 5	0
8.	Galvanised Corrugated Sheets, etc.	,, 7	6
9.	Metals	,, 5	0
10.	Paints and Drysalteries, etc. ...	,, 10	0
11.	Firebricks	,, 2	6

Tenders are due by Eleven a.m., on 19th May, 1925. Tender forms obtainable at above address. Fees not returnable. H 991

CITY OF LIVERPOOL.

The Corporation are prepared to receive

Tenders for the Supply and

DELIVERY of various classes of TRAMWAY MATERIAL, as under:—

Schedule No. 1.—Steel Tramway Rails.
Schedule No. 2.—Steel Tramway Rail Fishplates.
Schedule No. 3.—Steel Fishbolts.
Schedule No. 4.—Steel Tiebars.
Schedule No. 5.—Copper Bonds.

Firms are required to state clearly, when making application for the necessary Tender Forms, the name and number of the schedule for which they desire to be furnished with Tender Form.

Duplicate Forms of Tender for record purposes will NOT be supplied.

Tender Forms will be forwarded upon receipt of application in writing to:—

THE CITY ENGINEER,
Municipal Buildings, Dale Street,
Liverpool.

Tenders must be sealed and enclosed in the official envelopes provided, endorsed in accordance with the instructions given on the Form of Tender, and forwarded through the post addressed to:—

THE TOWN CLERK,
Municipal Buildings,
Liverpool.

Latest time and date for receipt of Tenders:—Ten o'clock a.m., on Friday, the 22nd May, 1925.

WALTER MOON,
Town Clerk.

29th April, 1925. H 983

PORT OF BRISTOL.

20,000 TON SILO GRANARY, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee are prepared to receive

Tenders for the Construction

of a FERRO-CONCRETE built SILO GRANARY of 20,000 tons capacity, carried on Ferro-Concrete piles.

On and after Friday, the 15th day of May, 1925, copies of the specification and contract drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol. *All cheques must be made payable to the Bristol Docks Committee.* The deposit of £5 will be returned to all *bona fide* Tenderers after the receipt of a Tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope endorsed, "Tender for Granary," addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings before Ten a.m., on Monday, the 15th day of June, 1925.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE,
Chief Engineer,
Port of Bristol.

Chief Engineer's Office,
Avonmouth Docks.
8th May, 1925. H 962

APPOINTMENTS OPEN.

THE UNIVERSITY OF SHEFFIELD.

ASSISTANT LECTURESHIP IN CIVIL ENGINEERING

The Council are about to

Appoint an Assistant Lecturer

in CIVIL ENGINEERING. Salary £300 per annum. Further particulars may be obtained from the undersigned, with whom applications should be lodged by the 22nd May.

W. M. GIBBONS, Registrar.
H 902

KENT EDUCATION COMMITTEE.

TECHNICAL INSTITUTE, TUNBRIDGE WELLS.

Wanted in September, a

full-time TEACHER of Engineering. Forms of application and particulars will be forwarded on receipt of a stamped addressed envelope, by Dr. J. LISTER, Technical Institute, Tunbridge Wells.

H. SALTER DAVIES,
Director of Education.
30th April, 1925. H 955

Technical Assistant

REQUIRED for writing technical descriptive matter and instructional handbooks on aircraft, aero-engines and aircraft equipment. Applicants must have engineering knowledge and experience, and a capacity for clear expression in good English. Some experience in writing for publication is desirable. Ex-service man preferred. Commencing salary £250 a year plus Civil Service bonus (giving a present total of £377) on the scale £250–£450 a year plus bonus. Apply, quoting A 62, to the SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants. H 968

THE GOVERNMENT OF BOMBAY require for October next a

Deputy Dredging Master

in connection with the Back Bay Reclamation Scheme. Applicants must have had considerable dredging experience, including Suction Cutter Dredgers, and must be fully capable of supervising extensive dredging operations and, if circumstances require, of taking charge of large Suction Cutter Dredger.

Four years' agreement. Salary at the rate of Rs. 800, rising by annual increments of Rs. 50 to Rs. 950 a calendar month. Free second-class passage to India and return passage on satisfactory termination of services. Provident Fund. The selected candidate will only be appointed subject to satisfactory references and to a strict medical examination.

Further particulars and forms of application should be obtained from the Secretary to the HIGH COMMISSIONER FOR INDIA, 42, Grosvenor Gardens, London, S.W.1. Last date for receipt of applications the 20th May, 1925. H 951

Wanted, by a Large Water-

WORKS Company (in England) a SUPERINTENDING INSPECTOR—permanent employment—about 35 years of age. Must be of active habits, good address and health, thoroughly acquainted with modern plumbing work, water fittings and installations in large business and trade establishments, as well as in private houses, and capable of advising consumers thereon. A thorough knowledge of waste detection in mains, domestic service pipes and fittings is essential. Applicants must also have a thorough mechanical knowledge of meters and be capable of supervising repairs thereto. The applicant appointed will also be required to supervise all meter readings (2000 meters) and keep the meter books from which accounts are made out. He will also be responsible for the Company's staff of Waste Inspectors (now nine in number), meter readers, repairers, etc., and he will be required to reside on the Company's premises and take duty outside office hours alternately with the Company's Mains Superintendent, and deal with complaints and breakdowns arising at such times. Salary £300, rising by yearly increments of £20 to £400, with house, rent and rates free, less 5 per cent. annual contribution to the Company's Superannuation Fund, the joining of which is compulsory. Applications will only be considered from those with good experience in similar work, and these must be received not later than May 23rd next and must be made on forms obtainable after May 2nd on application.—Address, H 901, Offices of ENGINEERING.

RESEARCH DEPARTMENT, WOOLWICH.

DIRECTORATE OF EXPLOSIVES RESEARCH.

Required, One Male

JUNIOR ASSISTANT.

Candidates should be University Graduates with a sound knowledge of modern Physics and preferably with a good Honours degree; experience in research work in some branch of Physics will be a recommendation.

Preference given to Ex-service men suitably qualified.

Salary from £160 to £220 per annum by annual increments of £10 and bonus (initial total emoluments at present £258-8-0).

Annual leave 24 days.

Applications in writing, accompanied by copies of not more than three testimonials, should be made to the

CHIEF SUPERINTENDENT,
Research Department,
Woolwich, S.E. 18,

from whom conditions of employment may be obtained. H 987

SUNDERLAND EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.
Department of Mechanical Engineering.

The Committee invite

Applications for the Position

of HEAD of the MECHANICAL ENGINEERING DEPARTMENT. Applicants must possess an Honours Degree and have had good drawing office and works experience.

The standard of the full-time day courses is that required for an honours University degree, and that of the part-time evening courses (T. 4 to T. 6) is suitable for Senior and Advanced students from the marine engineering drawing offices and works of the district. Experience in all types of prime movers, steam and oil, is desirable. There are courses also in advanced Structures, Hydraulics, etc.

Present Salary Scale £500-£50-£600, less five per cent. voluntary abatement. This Scale is subject to reconsideration in view of the Burnham Award, 1925.

Application forms can be obtained from the undersigned, and should be returned not later than Monday, 18th May, 1925.

HERBERT REED,
Chief Education Officer.

Education Offices,
15, John Street,
Sunderland.
22nd April, 1925. H 885

THE WORKS OF SIR WILLIAM ARROL AND CO. (SWANSEA), LIMITED.

SINCE the amount of business that constructional engineers are able to obtain is largely dependent on the prosperity of many types of industry, they have necessarily felt the general depression of recent years. In ordinary times extensions of works would be taking place and organisations overseas, British and foreign, markets. Conditions such as are now experienced, both at home and abroad, cannot persist for ever, and it is therefore of interest to see what is being done by the constructional engineers to prepare themselves for the time when prosperity returns. As an example, we may cite the recent erection of new structural works at Swansea. These have been built to meet the requirements of a new company, in which an additional outlet for the rolled steel sections and plates manufactured by Messrs. Baldwin's, Limited, at their Port Talbot and Margam Steel works.

For the works of the new company a site of 13 acres was chosen, adjoining Messrs. Baldwin's tinplate works, and near the shore to the east of the New King's Dock at Swansea. This is a particularly suitable place for such a works as there are facilities for transport by rail, road and sea. The Rhondda and Swansea Bay branch of the Great Western Railway Company runs close to the works. A main road between Port Talbot and Swansea is also available, and the ships coming to the docks provide the means of access to every part of the world.

The lay-out of the various workshops is clearly indicated in Fig. 1. When complete the works will comprise a template shop, 180 ft. long and 60 ft. wide, two open stock yards of 450 ft. in length and 45 ft. span, served by overhead electric cranes of 5 tons capacity, six main workshop bays, also 450 ft. by 45 ft. and of height 33 ft. to the eaves, in addition to an erecting shop 300 ft. long and 70 ft. wide, running across the ends of the six parallel main bays and served by two 20-ton overhead electric cranes. The general offices and the drawing offices are in a separate structure between the template shop and the main works. The buildings are completely encircled by full gauge railway tracks, while there are also narrow gauge service tracks equipped with bogie trucks, which are fitted with ball bearings, to facilitate the rapid handling of material. From these general statements and the study of the lay-out in Fig. 1, it will be appreciated that great care has been taken that the material used in the fabricating of structures can be taken into the works and the completed products removed with the minimum expenditure of time

Fig. 1.

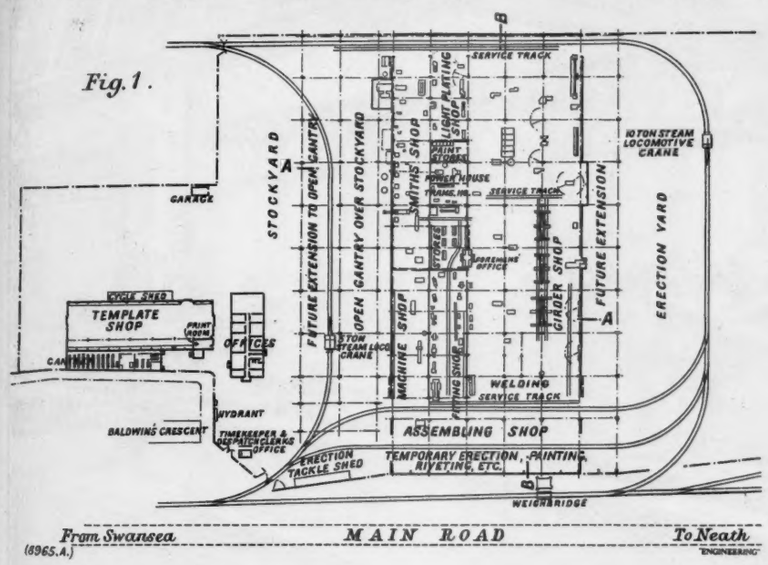


Fig. 2. SECTION ON A.A.

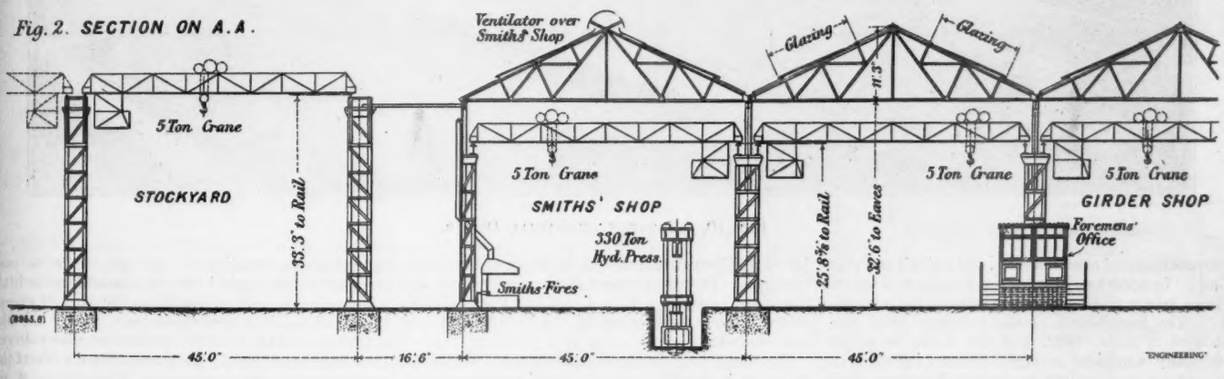
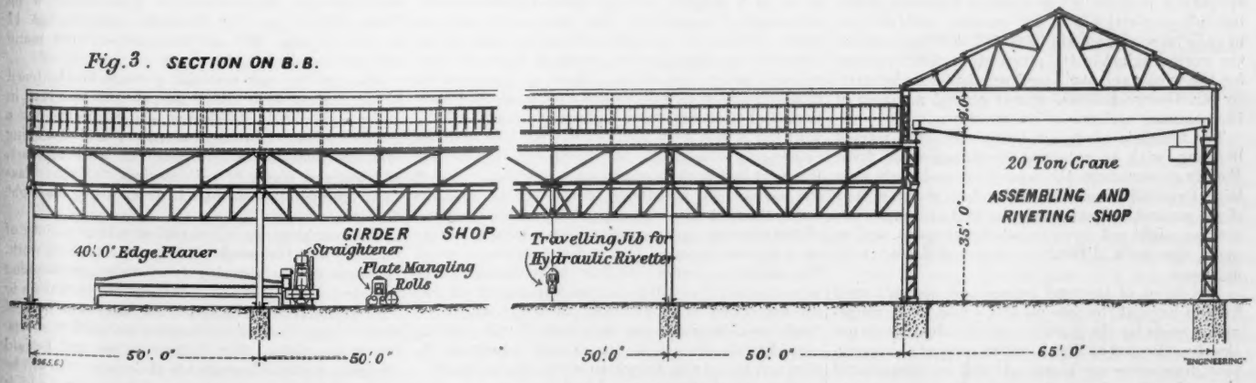


Fig. 3. SECTION ON B.B.



requiring new steel buildings would be coming into existence in every part of the country. That such is not the case at present is due to the fact that most manufacturers have works which are too big for the output which they can anticipate in the immediate future. Very little business may be expected in the home market for some time, and in consequence of this the structural engineers must look for an outlet for their products in a much wider sphere, and endeavour to obtain a substantial share of the orders available in the Sir William Arrol and Co., Limited, of Glasgow, the well-known bridge builders, and Messrs. Baldwin's, Limited, of South Wales, the iron masters, are jointly interested. The new company has the title Sir William Arrol and Co. (Swansea), Limited, and is under the control of Sir John Hunter, K.B.E., Colonel Sir William Charles Wright, K.B.E., C.B., Sir J. C. Davies, C.B.E., Mr. Henry Cunningham, M.Inst.C.E., and Mr. George Britton, M.I.Struct.E. It is their intention to enter largely into the structural steel overseas' trade and find and labour. It will later be seen that the locations of the machines have been determined solely by the consideration of reducing as far as possible the necessary handling of work in progress.

The buildings are entirely made of steel and covered with corrugated sheeting of 18 gauge, while a large proportion of the roof area is glazed. Good lighting, heating and ventilating are characteristic features of these works. They are divided up into sections housing the various departments, template shop, stock yard, main plating shop, light plating

THE WORKS OF SIR WILLIAM ARROL AND CO. (SWANSEA), LIMITED.

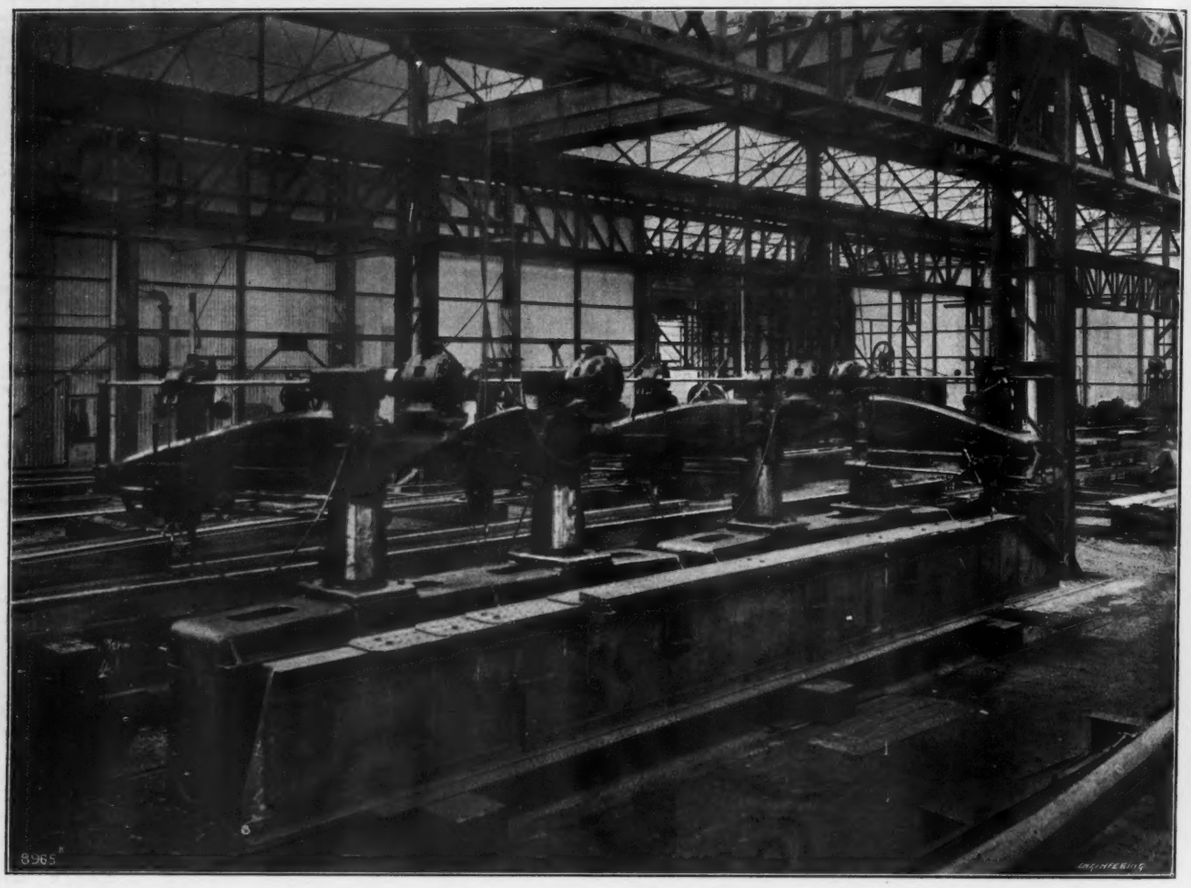


Fig. 10. Battery of Radial Drills.

shop, fitting and machine shop, and smith's and press shop. In addition, there are well-appointed central stores, power station, compressor and pump houses, &c. The foundations of the buildings were commenced in June, 1922, and the works were substantially complete in eight months, work being actually in progress in the shops in February, 1923, but full production was not possible until several months later. It should be stated that the whole of the work entailed in the preparation of the designs for the works and their equipment was undertaken by Mr. George Britton, who is general manager of the company and one of its directors.

The template shop is a light, airy, steel-framed building, with an extensive blackened wood floor. For its construction, the separate floor boards were laid diagonally, and the entire floor given a very slight amount of dishing in order that any expansive actions might not serve to cause high spots, and so make the work difficult of accomplishment with accuracy.

The forms of the roof trusses and uprights used for the bays of the general shops and the arrangements made for the gantries over the stock yards are clearly indicated in Fig. 2, where some of the important dimensions are given. It will be remembered from what has already been said, that there are to be six bays in the shops, of these five are now completed, as well as the two stock yards, although it has not been thought necessary to show them all in Fig. 2, from which, however, their construction can be clearly seen. A cross-section, Fig. 3, provides information on the construction adopted for the roof of the part of the works where assembling and riveting is done, as well as indicating the type of structure used for the longitudinal girders. It may here be stated that the cranes shown in position in the various sections of the works were all supplied by Sir William Arrol and Co., Limited, of Parkhead, Glasgow. The illustrations of the girder shop and one of the main bays, Figs. 4 and 5 on Plate XXXV, afford a good impression of the well-lighted and spacious works.

The shops were designed and laid out to facilitate, as far as is possible with the great variety of work with which it is likely the firm will have to deal, the direct movement of material from one end of the shops to the other, in the course of which it must undergo many operations. There are many works in which numerous passages of a piece of a structure, back and forwards, have to be made before all the work on it has been completed. All this involves expense, which might be eliminated if care and foresight had been shown in preparing the lay-out of the works. On the design of these Swansea works much thought has been expended and the positions of the various machines have been settled to obtain as near an approach to a direct route through the shops as could possibly be obtained. The advantage of this will be at once apparent to all who are concerned with the design of works, and when trade conditions become more normal will result in considerable savings to the mutual benefit of the firm and the people for whom structures are built.

Three bays of the general building are at present used as the main plating shops. In the first, work is undertaken on angle sections, while the second is intended to deal with joists and channels, and the third is laid out for work on heavy plates. A further bay will, it is hoped, be devoted to producing riveted pipe work, in which the firm anticipate that they will specialise. Naturally, for work on structural steel, which comprises straightening, cutting, holing and bending, the machines are of somewhat orthodox design, and the main factors considered in their selection were that they should be suited in capacity to the general work contemplated and should also be available with little increase in the cost of operation for work of exceptional dimensions or character. Nearly all the machines installed in the works are direct-driven from electric motors. We have selected a few of the machines for illustrations in Figs. 6 to 9 on Plate XXXVI, in Fig. 10 above, and in Figs. 11 to 13 on page 563, as examples of the many that are installed in the works.

Much of the raw material is rough straightened at the rolling mills before despatch to the yard in order to facilitate its storage and handling, but a number of straightening machines and mangling rolls are installed to complete the work on bars, sections and plates of various sizes. Of each class there are machines suitable for both heavy and light duties.

The machines used for cutting take a variety of forms to suit the needs of different classes of work. Of those of the shearing type there are cropping machines for angles and tees, notching machines to cut out metal not required in the flanges or webs of steel sections, as well as shears of the guillotine type for cutting plates. Fig. 6 shows a Craig and Donald cropping machine installed in the works. It will be observed that it is a double-ended machine and is driven by an independent electric motor through a belt drive. A heavy double-reduction gear carries the motion to the shaft on which are mounted the eccentrics, which raise and lower the shear blades. When the steel sections are to have their ends trued up, the work is performed in an end-milling machine of the type shown in Fig. 7. In this, a bed with grooves is provided for the clamping of the work in position. An independent electric motor drives, through a double back gear, a pinion shaft, which gives its motion to a gear wheel, on the shaft of

THE WORKS OF SIR WILLIAM ARROL AND CO. (SWANSEA), LIMITED.

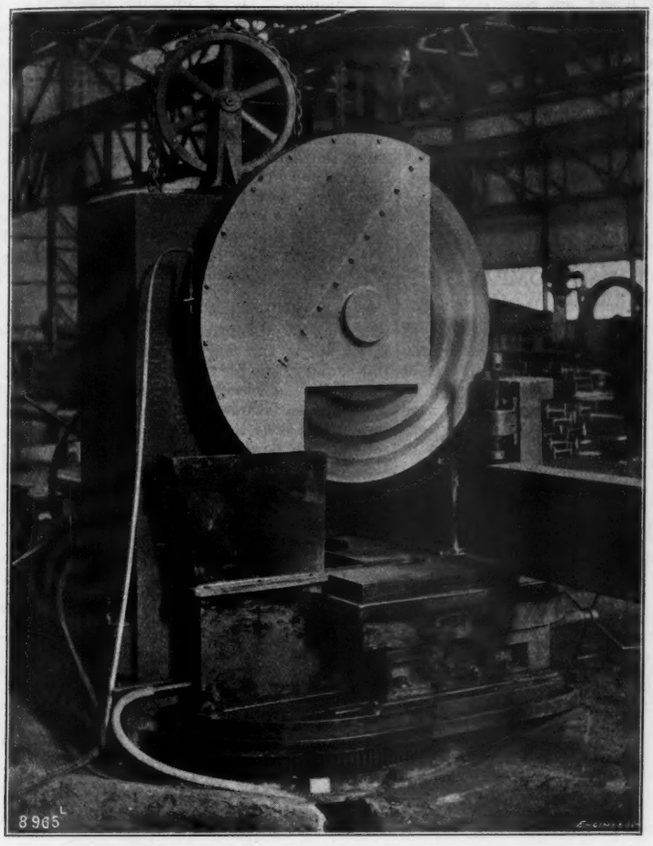
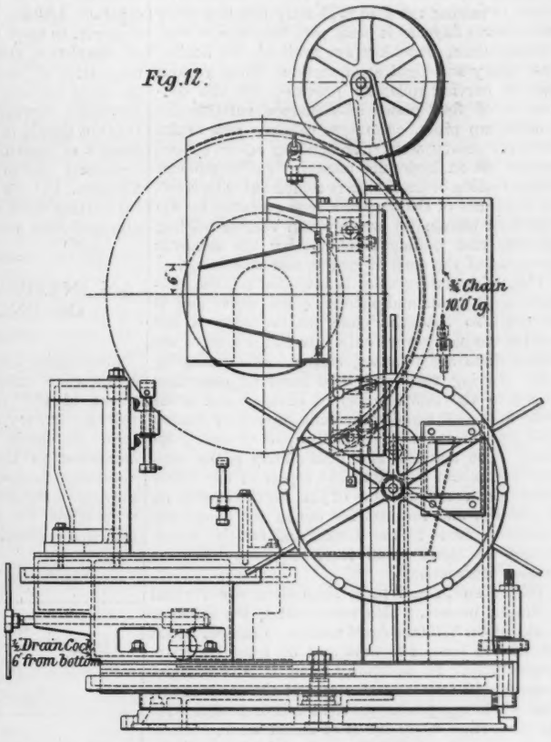
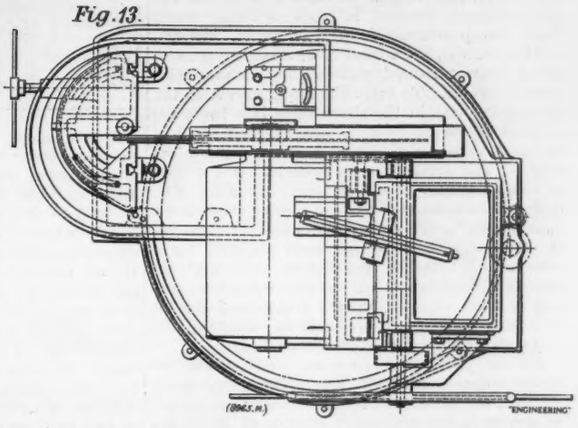


FIG. 11. HIGH-SPEED FRICTION DISC SAW.





which is mounted the face-plate carrying the cutters. One of the shearing machines of the guillotine type built by De Bergue and Co. of Manchester is shown in Fig. 8, Plate XXXVI. This is a heavy framed tool with a gear drive from the electric motor to the main shaft. As will be seen from the illustration, a stiff clamping beam is arranged to come into action to hold the plate in place prior to the actual movement of the shear-blade, which receives its motion from two heavy eccentrics at the two ends of the shaft.

It is frequently the case that parts of either the web or the flanges of steel sections have to be removed to give the accommodation which is required for the ends of other members of the structure. A representative machine of this notching type which is used for this purpose in the King's Dock works is shown in Fig. 9, Plate XXXVI. This is again of the geared electric motor drive type, and was built by Craig and Donald of Johnstone. A heavy flywheel steadies up the working and reduces the demands for power put on the electric motor. A solid bed with adjustable jacks is used for the accurate locating of the work prior to the cutting, while the machine controls are placed in such a position that the operator is able to see that the work is properly set. The shops also contain an ample provision of the customary cold saws for reducing joists, channels, and angles to accurate dimensions, and a friction saw of great interest which will be described later. The planing of the edges of plates is effected in machines of the latest type, the largest of which will accommodate a plate 40 ft.in length.

One of the batteries of drills is illustrated in Fig. 10 on page 562, with a cross-girder set in position for the drilling of the rivet-holes. This is an Asquith machine and has four separate drills mounted on a substantial bed. Separate motors serve each of the units, and all the feeds and speeds are under the immediate control of the operator at the ends of the radial arms. Throughout the works the drills are provided with direct motor drives, and there are three main batches of them mounted on wheeled bodies, so that, when necessary, they can be run in pairs backwards or forwards, covering a considerable area. In addition to this provision, throughout the shops all the drills are served by bogies having roller bearings to enable the material to be rapidly brought to the machines and removed after the work has been done on it. Whenever possible, arrangements have been made to reduce the time necessary in performing repetition work, and as an example it may be stated that for drilling work of this type a special adjustable jig, 40 ft. in length, has been made. It has been found that working on this system has proved much more flexible in operation, and entails the loss of much less time than is commonly the condition in the use of multiple drills and punches.

A disc saw of new design built by Clifton and Waddell to the requirements of the managing director of the firm, Mr. George Britton, is provided, which is capable of cutting through a steel joist, 24 in. by 7½ in., in just over one minute. This machine is illustrated in Fig. 11, while the details of its construction are shown in the adjoining Figs. 12 and 13. This has a cast-iron base and circular rack on which the main frame of the saw may be rotated by means of a ratchet and spur gear. By this provision the saw can be made to cut the material at any angle although the metal is always fed in on the same line. It will be appreciated that this system of mounting for the saw makes it unnecessary to have a great amount of space left unoccupied by other plant around the saw, which would be required if the machine were fixed. The main casting carries a heavy box-shaped pillar, upon which is mounted the saw disc, its shaft and the 60 h.p. electric motor used for its drive. The entire disc drive system and the motor are mounted on a slide and balanced by means of a cast-iron block suspended from a chain passing over the wheel, which is seen at the top of machine. The balance weight is enclosed within the rectangular pillar. By this arrangement it is possible to raise or lower the saw disc relatively to the work, and a suitable hand wheel and gearing is provided for the purpose. On the front of the saw bed is a semi-circular block carrying screw jacks for fixing the work to be cut. This block may also be rotated by means of a small hand-wheel. When it is desired to cut work at any particular angle, the saw is rotated and locked in position and the stop block is then rotated to suit the setting. As graduated discs are fitted, any specified angle for working may be obtained at will and with accuracy. For ease in handling the heavy joists and bars at the machine there are roller stallages.

The mild steel disc used for the saw runs at 1,500 revolutions per minute, giving a peripheral speed of nearly 30,000 ft. per minute and to facilitate its action in sawing the disc is slightly notched every two or three days, as is usual with this type of saw.

Straightening machines are available for dealing with heavy and light steel sections, while various sizes of curving rolls are provided for the conversion of flat plates into shapes suitable for building up pipes, chimneys, caissons and tanks. For very heavy work the bending is, of course, carried out in hydraulic presses. The equipment in this section of the works is completed with riveting machines of the squeezer type operated by hydraulic or pneumatic pressure and various milling, grinding and buffing machines for the accurate facing up of the ends of girders and stanchions.

The light plating shop is intended for the production of small and medium-sized work, and is provided so that the main plating shop is left free for the heavy work only. In this section of the works there are punches, shears, drills, mangling rolls, curving rolls and cold saws of capacities suited to the lighter class of circular and other plate work. A flanging machine capable of dealing with plates 8 ft. in length is also part of the equipment. The machine and fitting shop is provided with equipment suited to the repair of the works plant, for the manufacture of jigs, for the machining of castings and forgings for use in the completed structures made in the works, and for the manufacture of many small items necessary for the various contracts.

In the smith and press shop there are vertical hydraulic presses, which were built in the Glasgow works of Sir William Arrol and Co., Limited, which are of 330 tons, 110 tons and 60 tons' capacity, respectively. In addition, there is a horizontal press of 110 tons capacity and of the same make. The whole equipment provides ample facilities for the execution of all kinds of smith work, such as angle rings, joggled stiffeners and plates, and the light forgings needed in constructional work. There are pneumatic forging hammers, blowers, smith's hearths, open blast fires, stamping presses, and a large coal-fired plate-heating furnace with forced draught. To meet the requirements of the pneumatic plant in the shops there is a two-stage compressor, driven by an electric motor of 150 h.p. It has a capacity of 650 cub. ft. of free air per minute, and storage accommodation is provided so that a supply is at all times available. The hydraulic equipment consists of a set of three-throw pumps made by Sir William Arrol and Co., Limited, of Glasgow. These pumps were designed for a pressure of 1,150 lb. per square inch, and are electrically driven. An electric contactor gear and switches serve to put the pump into and out of action whenever necessary to maintain the accumulator height between defined limits.

In the yard there are two 5-ton locomotive steam cranes with 40-ft. jibs. These are useful items of the plant, and when necessary can be put to service in the temporary erection of structures for inspection.

We must not conclude our description of these well-equipped works without making some reference to work that has already been undertaken in them. One large contract already completed consisted in the construction of over 12,000 tons of riveted and welded pipes, for the Tata Company for their new hydro-electric scheme at Bhira, near Bombay. For this contract, the welded pipes were supplied by The British Mannesmann Tube Company of Newport, while the whole of the riveted pipes, bends, bellmouths, breeches pipes, &c., were made in the King's Dock Works. These pipes are of 84 in. and 58 in. diameter. Another contract, already completed, was a bridge alongside the main line of the Great Western Railway between Cardiff and Newport, crossing the River Ebbw, which will give access to new carriage cleaning sheds which are at present under erection. Other railway works have been built for the same company, as well as two of the station erections for the London Electric Railways. These works are but a few of the many that have already been prepared in these extensive and well-equipped works, but there are others of great importance, such as electrically-operated transporters and floating cranes, some of which are of such interest that we prefer to call attention to the features of their construction in separate articles. Sufficient has been said here, however, to show that the works are now in a state of completion and are available for the economic fabrication of steel structures of every type, from the steel sections and plates made by one of the associated companies having works in the district. It is not merely of importance to the large industrial district of South Wales that this, the first, large structural works should have been erected at Swansea, but its proximity to the docks enables the cutting down of all transport costs for contracts obtained from overseas.

AN INTERNATIONAL COMPARISON OF ENGINEERING WAGES.

(*Concluded from page* 531.)

Competitive Value of Wages.—In considering the competitive value of wages, the hourly rates of wages of the various countries converted into British currency at the prevalent rate of exchange form the basis of the comparison. Being unhampered in this inquiry by the necessity of obtaining comparable pre-war data, which was available only for a limited number of countries, it is possible to include in this comparison the principal engineering countries of the world.

TABLE III.—INTERNATIONAL HOURLY RATES AND COMPARATIVE PURCHASING POWER OF WAGES IN THE ENGINEERING INDUSTRY, DECEMBER, 1924.

Country.	Skilled.			Unskilled.			Comparative Purchasing Power (Table II).	
	Rate in National Currency.	Rate in Pence.	Index (Great Britain = 100).	Rate in National Currency.	Rate in Pence.	Index (Great Britain = 100).	Skilled.	Unskilled.
U.S.A. ..	0·688	34·0d.	234·0	0·528	26·0d.	243·0	219·6	217·5
Great Britain	14·5d.	14·5d.	100·0	10·25d.	10·25d.	100·0	100·0	100·0
Switzerland	1·35 frs.	13·4d.	92·4	1·08 frs.	10·72d.	104·6	—	—
Netherlands	0·64 florins	13·20d.	91·0	0·48 florins	9·98d.	96·6	—	—
Sweden ..	0·88 oehre	12·4d.	85·5	0·750 oehre	10·6d.	103·4	—	—
France ..	3·45 frs.	9·5d.	65·5	2·35 frs.	6·50d.	63·4	94·5	91·7
Germany ..	0·73 mks.	8·9d.	61·4	0·51 mks.	6·28d.	60·8	73·1	72·2
Belgium ..	3·02 frs.	7·6d.	52·4	2·29 frs.	5·8d.	56·6	72·4	78·0
Austria ..	475,000 krone	7·43d.	51·2	340,000 krone	5·33d.	52·0	—	—

A comparison of Tables II and III indicates the importance of the depreciation of exchanges in the realm of labour costs*. In France, for instance, while the purchasing value of wages is as 94·5 to 100, the competitive value is as 65·5 to 100—that is to say, that the French engineering employer, while paying little more than half the British employer's wage bill, is enabled to give his workpeople substantially the same standard of living as the British workpeople enjoy. But these rates of wages by themselves do not give the full measure of the foreign manufacturers' advantages. It is necessary also to take into consideration the working conditions which obtain in the different countries. It would be idle to attempt to put any precise value on these items, but the general tendency is made clear from the following table, and in the absence of earnings figures gives a more accurate idea of comparative labour costs than the bare wage-rates alone.

TABLE IV.—*International Working Conditions in the Engineering Industry.*

Country.	Percentage Addition to Time Rates on Account of—	
	Overtime.	Nightshift.
Great Britain..	50 per cent. to midnight; 100 per cent. thereafter	33⅓ per cent.
Belgium ..	First two hours 25 per cent.; thereafter 50 per cent.	20 per cent.
Germany ..	First three hours 25 per cent.; thereafter 50 per cent.	—
Holland ..	First two hours 25 per cent.; thereafter 50 per cent.	Nil.
Italy	First two hours 20 per cent.; next three hours 50 per cent.; thereafter 100 per cent.	20 per cent.
Switzerland ..	25 per cent.	—

There are certain other factors which, though not susceptible of tabular statement, deserve consideration. The most important of these is the excess of payment by results earnings over the time rate about which, as stated above, the evidence is incomplete. It is credibly stated that in Germany such earnings only amount to 15 per cent. or 20 per cent. above the time rates—a much lower figure than in this country. The next in importance is the loose application of the 48-hour week, particularly in France and Belgium. In Germany, it is frankly admitted, that a longer week is worked and this has been taken into consideration in calculating the hourly rates; but it is notorious that Belgium and France, while nominally working a 48-hour week, actually allow considerable latitude of which full advantage is taken. For this reason it is probable that the relationship given in Table III of the hourly wage rates in France and Belgium to those of Great Britain and Germany tends to be too high.

Taking all these factors together, it would appear that from a competitive point of view Continental wages are in the neighbourhood of half those in this country. So far no account has been taken of the relative efficiency of labour in the countries compared—a counterbalancing factor of great importance since the British workman is generally recognised to be supreme in this respect. Assuming that the British engineering industry was holding its own in competition prior to the war and that other elements of cost were equal, the pre-war ratio of competitive wages should be roughly a gauge of their pre-war comparative efficiency. This ratio was for skilled workmen—Germany 75, France 69 and Belgium 52, as compared with Great Britain 100. From Table III it will be seen that these ratios are now—Germany 61·4, France 65·5, and Belgium 52·4. Leaving out of account, therefore, the more advantageous working conditions enjoyed by our rivals, to which allusion has been made above, the competitive position of France and Germany is more favourable than before the war, and in Belgium it is substantially the same. Moreover, there is scarcely room for doubt that the stimulus of the war has tended to bridge the gap which formerly existed between British and foreign labour efficiency in engineering.

It would be idle to attempt to reach any great precision, let alone finality, on such a question, but even with these limitations certain important conclusions emerge from this comparison of international engineering wages. In the first place, when the upheavals of the intervening period are considered, there is a striking similarity between the pre-war and post-war relationships of British to foreign wages. Secondly, to the extent that the relationship has changed, the conditions prevailing on the Continent in 1924 gave foreign manufacturers a greater advantage over their British rivals than the corresponding conditions in 1913. Thirdly, that advantage to foreign employers was not accompanied by a corresponding disadvantage to foreign workpeople in terms of standard of living.

From the first of these conclusions it is legitimate to infer that Mr. Hichens is correct in supposing that wages and hours of work tend to maintain a constant relationship, if not equality, as between the various manufacturing countries; from the second, that British engineering wages even at their present level must be having an adverse effect on the competitive power of the industry and that any further increase would be economically unjustifiable if other factors remained unchanged; and from

* [For convenience, the figures from Table II are reproduced as the two last columns in Table III.—ED.E.]

the third, that it would be unwise to assume that any such justification is likely to arise in the near future from the raising of Continental wages.

It would follow then that the "new normal" international relationship of engineering wages should not be wantonly disturbed in an attempt to restore the pre-war relationship between the wages of industries in this country. Within the existing wage bill of the industry there may be scope for adjustment and the removal of anomalous conditions which were certain to be evolved from war dislocation. But in the aggregate the present wage bill, as pointed out above, provides equivalent real earnings to those in 1914. Further improvement beyond the 1914 level to which engineering workpeople naturally aspire will only be on a sound basis and enduring if it is the result of a decrease in the cost of living giving them a greater purchasing power with their present wages. The cost of living in turn cannot be expected to fall until public opinion insists upon and is prepared to enforce the reduction of wages in sheltered industries to a level more in accordance with the value of their contribution to national productivity.

THE REGULATION OF THE MURRAY RIVER.

(*Concluded from page* 535.)

IN our first article of this series (page 371 *ante*) it was stated that the largest individual undertaking in connection with the present programme of works for the control of the Murray River was the Hume or Mitta Mitta Reservoir in the upper reaches of the river. The selection of the site for this reservoir necessitated exhaustive investigation of the possibilities of the upper water shed of the Murray. A number of alternative proposals were considered, not only as regards the actual site, but also as to the character of the work. Some schemes proposed only one dam, while others suggested a number of small reservoirs. The question of cost of construction ruled out the latter, however, while no less than 28 possible sites for a single dam were examined. The catchment area, of course, varied with the several schemes. The idea of substituting various smaller works for the one larger one was recommended by the fact that less valuable land would be covered, while no serious difficulties would arise with regard to communication with areas rendered inaccessible by the impounded waters. Thus, one scheme proposed three sites in the Upper Murray watershed—Black Jack, with a catchment area of 93 sq. miles, Geebi with 172 sq. miles, Tom Groggin with 369 sq. miles, and one site on the Upper Mitta Mitta River. The latter had a catchment of 1,650 sq. miles, so that with all four dams constructed, waters from an area of 2,284 sq. miles would be available. On the other hand, by siting a single reservoir just below the junction of the Murray and the Mitta Mitta six miles east of Albury, a catchment area of about 6,000 sq. miles is available, though valuable land will be submerged, and as the reservoir will back the waters up long arms on both rivers, the land inside the fork will be inaccessible, except by water or very circuitous land routes, so that its use may be handicapped to some extent.

The actual area submerged will be some 30,000 acres (approximately 16,820 acres on the Murray and 13,480 acres on the Mitta Mitta) of a tract of country stated to be extremely prosperous and well developed. The great storage possibilities of the site have, however, outweighed other factors, the site chosen rendering possible the impounding of no less than 1,098,500 acre-feet, or 272,250 million gallons. This will be effected by means of a dam about 3,800 ft. long, an elevation of which is shown in Fig. 102 below. This dam will have a height above the bottom of the river channel of some 93 ft., the crest being at elevation 614 R.L., as shown in Fig. 103. As the question has been raised of providing still further storage, a recommendation was made in August last that the work of construction proceed in a manner suitable for the building of a dam capable of impounding 2,000,000 acre-feet, and that the matter be finally settled at the end of three years. The present design is therefore, presumably subject to modification. The dam is constructed of a length of embankment with core wall of about 2,700 ft. on the Victorian side of the interstate boundary. This runs, as shown in Fig. 102, exactly to the boundary, after which, on the New South Wales side, is a 740-ft. length of gravity section dam to be fitted with flood gates. Next to this comes an outlet section of 161 ft., followed by a small run of embankment tailing off into rising ground. The dam follows the best line for foundations indicated by careful exploration by bores. In plan, it is straight on both wings, but the central portion is curved, the arch facing up-stream. The whole of the gravity and spillway section on the New South Wales side is straight. The central run of about 1,300 ft., which comes next, is curved to a radius of 3,000 ft., the remainder being again straight. The spillway will consist of 31 sluices of 20-ft. width by 15-ft. rise. The draw-off pipes are to be eight in number, each 6 ft. in diameter. The full supply level of the reservoir for the 1,100,000 acre-feet capacity is R.L. 602. For any level above R.L. 553·5, the outlets have a discharge capacity per month of about double actual requirements. The spillway and outlet works situated on the New South Wales side cross the old river channel. This location was chosen on account of the foundations procurable on this side being superior to those on the Victorian side.

The main embankment of which a section is given in Fig. 103, is an earth fill with reinforced concrete core wall. It is 32 ft. wide at the top and carries a roadway. The two toes are made of large rock, the main body being of earth with a centre of selected material. The upstream face is finished to a slope of 3 to 1 below normal full supply level, increasing to 2 to 1 above this. On the downstream side the slopes are 2½ to 1 for the greater part, changing to 2 to 1 for the upper section. The upstream slope is faced with heavy stones of about 1 cub. ft. bedded on 4 in. spalls or broken metal, the joints being packed with concrete after preliminary settlement has taken place. The core wall is carried everywhere down to hard granite, through a layer of varying thickness of decomposed granite. This at some points has necessitated carrying the work to considerable depths, as shown by Fig. 102, the lowest point extending to about 85 ft. below normal ground level. The core wall is 6 ft. thick, parallel for the lower part in the decomposed granite and extending at least 5 ft. into the solid rock. Above the stratum of decomposed rock the wall is tapered, its thickness contracting to 2 ft. at the top. Over the tapered part the wall is reinforced with vertical and horizontal ⅝ in. bars, 6 in. away from the front and back faces. The spacing of these is 8 in. horizontally and 14 in. vertically.

A feature of the core wall is the inspection and drainage tunnel on the down stream face, the position of which is shown in dotted lines in Fig. 102, its position being indicated in Fig. 103, about on a level with the upper surface of the layer of sandy loam and gravel. A detail to a larger scale is given of this in Fig. 104, from which it will be seen that the interior height is 6 ft. 6 in., while the outer wall is practically semi-circular, 1 ft. thick on the horizontal diameter and thickening up at the top and bottom to run out into the main structure. The tunnel wall is reinforced with horizontal ½-in. rods of 10-in. pitch, while curved ⅞-in. rods anchored into the core wall extend through the tunnel wall close to the outer and inner faces at 10 in. pitch, as shown in Fig. 104. The horizontal reinforcement is increased to ⅞-in. rods near the springings of the tunnel wall. A good illustration of the tunnel is

Fig.102. DOWNSTREAM ELEVATION OF DAM.

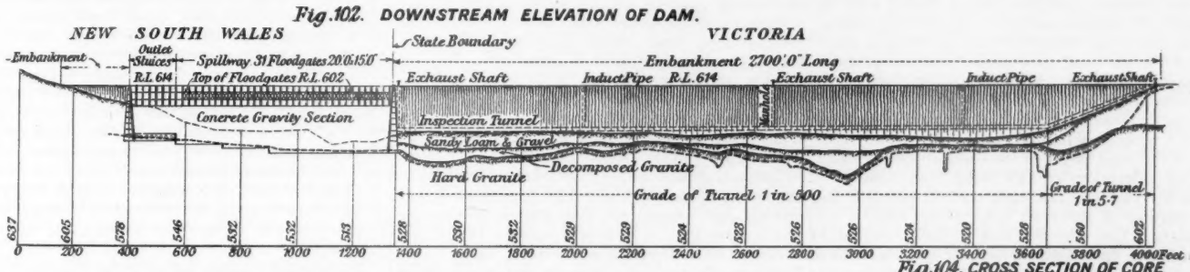


Fig.103. TYPICAL CROSS SECTION OF EARTH DAM.

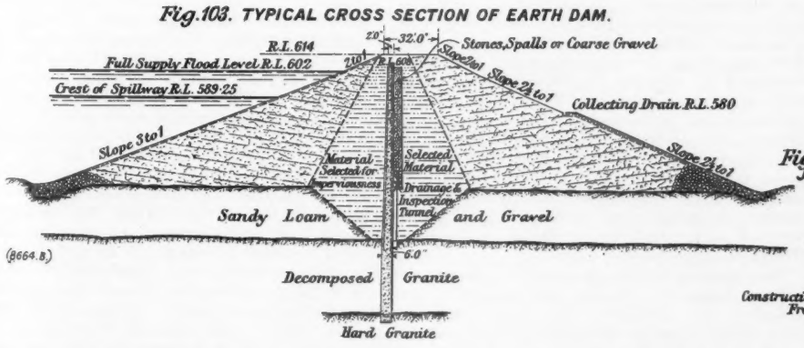


Fig.104. CROSS SECTION OF CORE WALL DRAINAGE AND INSPECTION TUNNEL.

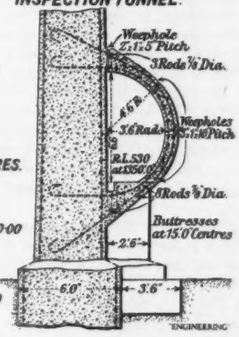
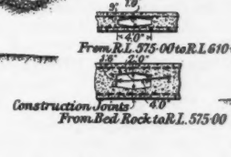


Fig.105. CORE WALL JOINTS AT 50'0" CENTRES.



also given in Fig. 106, page 576, which shows the bulge on the partly-built core wall extending into the distance. Above the tunnel and close to the face of the core wall, is a 6 ft. thickness of stone spalls and coarse gravel laid with the object of collecting any water working through the core wall, and carrying it down to the drainage tunnel. On the upper side this is finished, as shown in Fig. 104 with a small collecting channel with 2 in. by 1 in. weepholes at 5 in. pitch communicating with the tunnel. Three other lines of weepholes are provided in the curved wall. A channel is also laid in the floor, and water finding its way to the interior is led off to be discharged finally into the river. The tunnel is laid on a gradient. For the first 400 ft. or so on the Victoria side the slope is 1 in 5·7, but for the remainder it is 1 in 500. Manholes and shafts give access to the tunnel at various points. The core wall is buttressed at 15 ft. intervals, the buttresses being 2 ft. 6 in. deep. This is increased at the footings to 3 ft. 6 in. The buttresses are clearly visible in Fig. 106.

At 50-ft. intervals in the length of the core wall construction joints have been left. These joints take the form shown in the details in Fig. 105, in which the upper detail shows the type of joint used between R.L.'s 575 and 610, while the lower shows the joint adopted below R.L. 575 to bed rock. Both are vertical cavities 4 ft. long, filled with concrete after the main structure has had ample time to contract to the greatest extent in maturing.

In our last article we stated that the works on the Murray, where the river formed the boundary between Victoria and New South Wales, were in theory to be constructed jointly by the two states. In practice, it has worked out on the whole as more convenient for each to organise and concentrate on particular sites, with one exception. This exception is the work now under consideration, but even in this case the term joint construction can only be used in a limited sense. As a matter of fact, of the total length of the dam, about one-third is being undertaken by New South Wales, and two-thirds by Victoria, *i.e.*, each state is constructing that portion of the work lying on its side of the boundary. The effect of this is that New South Wales has in hand the whole of the gravity section spillway and outlet section, while Victoria is constructing the long embankment and core wall. On the Victorian section work has been proceeding steadily since 1921, and a large amount of the site has been stripped and material placed in the outer toes, since then. Fig. 107, on page 576, shows work in progress on the site, with the core wall and trench for selected core material, on the right. The material for the fill is excavated by 2¾-cub. yard steam shovels, and conveyed to the dumping point in side-dumping cars on a 3 ft. 6-in. track, being spread and consolidated by horse-drawn wheel scoops.

The force employed on the Victorian section numbers about 400 men. Most of them live on the works and are housed in a very comfortable township built by the Victorian Authority. The general view, Fig. 108, will give some idea of this and of the country surrounding the site. Single men are housed in wooden barracks, provided with shower baths, recreation rooms, wash-houses for clothes, and all sanitary conveniences. A Government boarding house enables them to procure good meals at the actual cost of the food consumed, utensils, building, and cooks being furnished by the Constructing Authority. Married staff and workmen are housed in three- to six-roomed cottages at a moderate rental. The streets are planted with trees and electric light, and water supplies are laid throughout the township. Materials are brought to the works by a branch line of the Victorian (broad) gauge system. This is on the left of Fig. 108.

On the New South Wales side a good quarry has been opened up, where crushing plant, &c., has been installed, having a capacity sufficient to meet the mixer requirements at the dam site for the gravity section portion of the dam of 1,000 cub. yards per eight-hour day. A 10-ton electric Lidgerwood-type cableway commands the whole of this part of the work.

In concluding this review of the works completed and in progress, we wish to acknowledge our indebtedness to Mr. E. M. de Burgh (New South Wales), Mr. J. G. Stewart (South Australia), and Mr. J. S. Dethridge (Victoria), M.M.Inst.C.E., for kindly placing the information and official drawings and photographs at our disposal.

LITERATURE.

A Popular History of American Invention. In two volumes. Edited by WALDEMAR KAEMPFFERT. Vol. I. *Transportation, Communication and Power.* Vol. II. *Material Resources and Labour-Saving Machines.* New York and London. Charles Scribner's Sons. [Price 3*l.* 3*s.* net.]

PROBABLY no one man ever invented anything—he is guided by experience and instructed by science acquired in many ways. Growth is gradual, but not uniformly progressive, and when the combination of trial and observation lead to the improvement and adaptation of mechanical means, we recognise the result as an invention. Many hands and many heads contribute unwittingly to the evolution of the successful machine. To trace these steps and to exhibit their cumulative effect is a fascinating task, and in these two handsome volumes, the various authors have used their opportunity with discretion, and good effect. Some exception might be taken to the expression "American Invention" in the title. The United States have profited by the labours of men and nations in many parts of the world, and invention did not begin with the Declaration of Independence. Over her capacious lands, the culture, the experience, the mechanical training of all nations has spread, influencing and shaping with excellent results that heterogeneous mass which is proud, and rightly proud, to claim the title of American. But the authors scarcely do justice to what has been introduced into the country. The contributing influence of England in many departments of engineering is acknowledged, but it might be inferred that other nations have been passive spectators. France, Belgium, Germany have exhibited great mechanical ingenuity, from which America has profited, but scarcely half-a-dozen of their representative men find a place in this historical record. One of the authors, Mr. Russel Bond, claims that by an American invention is meant one designed to solve an American problem. This definition might well apply to the processes that have made lumbering a successful industry, for lumbering presents problems with which the early settlers had to struggle untutored by previous experience. But Guttenburg or Coster, of whom Mr. James Collins writes pleasantly and informingly, did not use separate types to save American labour, nor did Hargreaves and Arkwright work at their self-imposed tasks to assist American enterprise. On the other hand, the cotton gin of Eli Whitney was distinctly an American product, a labour-saving machine originally constructed and effectively employed to promote American commerce and industry.

Two features become prominent as the various authors depict the changes that have overtaken manufacturing enterprise. One is the frequency with which chance has favoured the lucky inventor at the moment when defeat seemed imminent. There are, of course, two sides to this lucky intervention, but generally we hear only of the successes. Yet chance must just as frequently have operated to give the death blow to the hopes of the luckless inventor, but history does not care to preserve the story of failure and impotence. Fitch, whose tale is told with dramatic force by Mr. J. W. Harrington, affords one of these unfortunate instances. He had visions, and saw how paddles fitted to a boat and driven by steam, could be made to navigate the Mississippi, and provide a highway for commerce. He actually made a model, but his scheme was killed by ridicule. He came as near to an inventor as it was possible, and left a thought by which others profited. He failed because there was too great a gap between the methods of transport in his day and his proposals. The step required to be taken was too great, men had not been prepared for it by gradual progress, or in the usual phrase, he was before his time.

The second feature is the frequency with which dishonesty and greed have robbed the successful inventor of the due reward of his ingenuity. The defence of patent rights has always been a difficult matter and a heavy tax on the inventor, but when the States were a young community, infringement appears to have been open and unashamed. Eli Whitney declared that he made no profit out of his machines, and his workshop was wilfully burnt down, and his models destroyed. Men refused to come into Court and testify to the most obvious facts. He relates that he had great trouble to prove that his invention was used in Georgia, "although there were three separate sets in operation within 50 yards of the building in which the Court sat, and all so near that the rattling of the wheels was distinctly heard on the steps of the Court house." This is one of the most flagrant cases, but the same tale is told over and over again, and we can only infer that commercial morality was at a low ebb. Debt and discouragement dogged the footsteps of many, reward and encouragement was the lot of few.

Biographical traits and local colour give great vivacity to these volumes, and it is to be hoped that a reference to these will serve to indicate the character of the work, for it is impossible to deal in any adequate way with the varied contents which cover many subjects, treated by authorities who must have been acquainted with many of the men whose work is described. The editor treats the general subject in five separate sections. The first is devoted to the evolution of transport, wherein details are provided that carry us back to the days of Trevithick and Stephenson on land, of Fulton and Livingston on water, and of Cayley and Lilienthal in air, and forward to days when facilities and convenience are realised of which those early giants could only have dreamt. And with this evidence before us it is impossible not to ask what will be the next step, and Mr. Comerford Martin replies that in a few years' time there will be no steam railroads left. The triumph of one generation becomes the commonplace of the next and whatever labour and thought have done to perfect a form of locomotion will be scrapped, to afford opportunity for more powerful weapons to minister to the demand for greater rapidity and economy.

The second division surveys the growth of the methods of communication of thought from the time when the printed page revived learning and stimulated research. The salient advances in the improvement of the telegraph and telephone are described, and the methods of wireless communication explored. Photography and its adaptation to kinematography are included in this section, and the possibilities of the typewriter now and in the future are discussed. Electric motors, we are told, will probably take the place of muscular power, the roller will disappear, and the typewriter of to-morrow will be adapted to flat writing. The section on "Power" is rather short, seeing that the fields covered by steam and electricity are both discussed. Electricity in its day rose rapidly in favour, but it is curious to note that in the early days of settlement coal was undervalued. As late as the beginning of last century two boatloads were shipped to Philadelphia from the Lehigh Coal Mine, and could not find a market. People were ridiculed for buying the "black stones," and these were subsequently used on the side walks instead of gravel. The output is now 700,000,000 tons annually, and shows no signs of slackening.

The second volume opens with a very interesting section devoted to the exploiting of material sources, in which is traced by competent authorities the processes employed in mining gold and silver, and of some of the baser metals, together with coal and paraffin. The history of the latter exhibits in various ways the peculiar merits of American ingenuity and dogged perseverance. In this section is to be found an admission of the value of science in assisting human endeavour and manual skill. As a rule the various authors have invited us to consider unaided individual effort. We have been asked to admire the tireless zeal and indomitable resolution which has carried the inventor to his goal. We readily yield our unstinted admiration to the untrained exertion of individuals, but the influence of science in indicating the line of action

and in directing energy is not so fully emphasised. The last section—that on automatic labour-saving devices—is peculiarly illustrative of the trend of American invention. The value of standardisation of parts and of "quantity production" appeals forcibly to the American mind. The problem of producing vast quantities of metal articles cheaply in the face of high labour costs is very effectively understood and is certainly very effectively carried out in the trans-Atlantic workshop.

Elektrische Maschinen. First Volume. *Allgemeine Berechnungs-Elemente, Die Gleichstrommaschinen.* By RUDOLF RICHTER, Professor an der Technischen Hochschule in Karlsruhe, Berlin: Julius Springer. [Price 27 gold marks.]

PROFESSOR RICHTER'S previous book on windings prompts us to expect a great amount of valuable information in his new publication dealing with the principles of design and performance of electrical machinery. This expectation is fully realised as the book gives a complete and yet concise treatment of these subjects. As the material is admirably arranged, readers will find the book particularly useful for reference on special problems connected with the design and behaviour of such plant. Richter is the successor of Professor Arnold in his chair of electrical engineering at Karlsruhe, and his book may be considered as a fitting replacement of the well-known books of this author, which were, when first published, quite unique, though they are now getting somewhat out of date in parts.

In many ways the book is a distinct advance on these earlier publications as some merely theoretical and less important subjects have been cut out altogether, and the author has restricted himself to the main points in a comprehensive manner. The book, certainly constitutes the most important publication of its class since the appearance of Professor Mile Walker's book on "Specification and Design of Dynamo-Electric Machinery." If one compares these two books dealing with the same subject, one finds that Miles Walker treats designing as an art, which it undoubtedly is, based on scientific considerations and foundations, and gives us a book which shows students the actual procedure of design of electrical machines. In other words, there is a preponderance of the practical side and of the application of the theory to actual examples of everyday design. In Richter's book the theory itself predominates and the application to actual designs is entirely omitted. It will, however, give an attentive student a thorough grounding with a completeness which canont be found in any similar publication. Even the specialist in design will find in the book a wonderful collection of precise and comparatively simple solutions of many of the intricate questions which must continue to crop up in practical work.

At present only the first volume of the book has appeared, which deals with the general principles of all electrical machines and transformers, and gives full details of the design and general characteristics of direct-current machines in particular. A second volume on alternating-current machines and transformers is to follow. Starting with the fundamentals of electric engineering and a short and comprehensive treatment of windings, the author gives a thorough and clear analysis of the main questions, which determine the design of electrical machines. We may mention particularly the chapters on Heating of Machines, Iron Losses in all parts of Dynamos including those due to tooth pulsations, Eddy Current Losses in A.C. and D.C. machines, and a full discussion of the commutation problem. The calculation and allowance for eddy current losses in direct-current machines has often been entirely neglected, an omission which has led to heating troubles on machines of high periodicities. We find in this book a short and sufficiently accurate treatment of this difficult question which gives the necessary indications of how these losses can easily be ascertained. The chapter on Heating starts—as is the rule throughout the book—with first principles and develops methods to pre-determine the temperature rise of machines based on these and not merely on data derived from previous experience or tests, so that the formula given may be adapted for special cases.

As is fitting in a book mainly devoted to direct-current machines, the question of commutation is given fullest attention and a comparatively large part of the volume is devoted to it. The author has rightly discarded many previous conceptions and gives his own theory of commutation. He determines a mean E.M.F. to be induced in the short circuited coils to obtain best conditions for commutation, taking into consideration the mutual inductance of all coils short circuited by the brushes, and gives tables which enable the designer to make allowance for this influence for all classes of windings. The various factors which cause variations of the field in the commutation zone are fully discussed and means to reduce these to a minimum are indicated. A detailed description of the procedure of the design of a direct-current machine and a full schedule of the literature on the subjects treated in the book concludes the volume. We are finally given a complete index of the meaning of all letters used in formulæ, together with references of the pages, where they are first introduced. The importance of this index cannot be overrated, as it enables readers to find information on various subjects without spending much valuable time (as is often necessary) purely to familiarise themselves with the meaning of the nomenclature.

Automobile Engines, &c. (Vol. I.) By ARTHUR W. JUDGE, Assoc. Royal College of Science, London, and late Senior Technical Assistant, Air Ministry, &c. London: Chapman and Hall, Limited. [Price 4s. net.]

IN a foreword to this book the author explains that this little work of 189 pages, including a good index, is the first of a series of four motor manuals, intended to present in a simple and non-technical manner the elementary aspect of each branch of the subject. The author's long experience as an instructor in engineering is accountable for the style of the treatment of the subject. The matter, though divided into seven chapters of text, is arranged in short and mostly terse paragraphs. The numerous illustrations, chiefly drawings, are in keeping with the order of the text. The print is easily legible, the style is interesting, and the explanations are as a rule lucid. From its purpose the work is necessarily free from mathematics, which both lightens the reviewer's task, and no doubt also, in this age of hurry and tabloid knowledge, will the more commend it to the large number of owner-drivers of light cars and motor-cycles.

The book is up to date, since it deals briefly with super-charging or forced induction, and with such recent engine types as the Peugeot-Tartrais, which attracted attention some while ago, following certain trials. A comparative test of two large Peugeot cars with similar chassis, one being fitted with a standard Peugeot engine and the other with a Tartrais two-cycle, valveless, heavy-fuel engine with a scavenging air compressor, showed a marked fuel-cost economy in favour of the latter engine; the standard petrol type costing 1·14 pence per mile with a consumption-mileage rate of 18·87 m.p.g., against 0·426 pence per mile and 19·88 m.p.g. for the Tartrais engine.

Quite a number of types of British engines, mostly post-war, are briefly dealt with, including the Still with its combination of internal-combustion and steam engine features. Chapter III deals with this subject, and the types reviewed range from the simple single-cylinder to the eight-cylinder types with cylinders diagonal in two sets of four, and the more recent eight-in-line arrangement. As the book is an epitome of more or less recent practice, the inclusion is permissible of some lay-outs that, up till now, have not become commercial practice. It is indeed well to have these "novelties" included, if only for the historic value which may attach to them for the student. We note that the well-known names of Thornycroft and Maudslay, mentioned among makers of engines in this section, unfortunately are not correctly spelt.

Chapters I and II deal respectively, and in sequence, with the theory and working of the petrol motor and its components. The chemistry of petrol and combustion is briefly explained, and a table given of the properties of various liquid and gaseous fuels in the petrol group. Incidentally it is stated in this table that a mixture of medium (density) petrol of the heat value of 19,000 B.Th.U. per lb., has a compression range up to 140·5 lb. per square inch. This figure seems somewhat high in view of the average engine maker's practice, and the too marked tendency of some high-speed *multum in parvo* engines to pre-ignition, even at present normal rates. In a comparative table of brake-thermal efficiency values of various engine types, the petrol motors range from 20 per cent. to 27 per cent., which is about midway between the 4 per cent. to 6 per cent. for steam locomotives at the bottom of the scale, and 32 per cent. to 35 per cent. for the Still hybrid engine, and 30 per cent. to 36 per cent. for the Diesel engine at the top of the scale. The author is well advised in pointing out for the instruction of car users how the heat in the fuel is utilised, with a view to inculcating care in the maintenance of engines within the limits of a possible everyday efficiency. Taking as a symbol in this connection the contents of a 2-gallon petrol tin he presents it ruled off in scale divisions, showing how the fuel heat is disposed of in the engine. As much as 40 per cent. heat is lost to the exhaust, 28 per cent. to the cooling water; friction and radiation between them absorb 8 per cent., leaving 24 per cent. for brake horsepower.

Chapter V deals with engine cooling. In this the points are dealt with both descriptively and with comments on various forms and systems, and some useful hints are given on anti-freezing solutions, and dopes for stopping leakage.

Chapters VI and VII deal briefly with engine testing, maintenance and tuning. A simple form of Prony brake with formula is shown, together with that indispensable accessory, a cylinder compression and explosion pressure gauge. A more elaborate means of analysis is by the Hopkinson optical indicator, which is explained, with a specimen diagram accompanying it.

The work closes with some instructions of immediate interest to owner-drivers who look after their cars. Altogether this is a useful book and a model for the subsequent volumes of this proposed series.

THE MOUNT WILSON OBSERVATORY REPORT.

IN all astronomical enquiries for which large optical power is essential and great delicacy of manipulation indispensable, we await the decision of the Mount Wilson observers, whose annual report furnishes the solutions to many vexed problems and provides the latest information concerning the construction and the behaviour of the cosmos. Naturally we turn to this authoritative source to learn whether the Einstein theory of general relativity has advanced or receded in public confidence. Two of the proposed criteria have, we know, been answered decisively in favour of Einstein, but as to the third, the gravitational shift of the lines in the solar spectrum, some doubt remained owing to the difficulty of eliminating all sources of error in such minute and delicate observations. The last lingering doubt, arising from the observation of the stronger lines showing greater, and the weaker lines less, displacement than theory required, has now been satisfactorily removed. The results of Professors Michelson and Gale, referred to on page 549 *ante*, however, indicate that, in opposition to the contentions of many relativists, rotations are absolute.

The sunspots have revealed only a portion of the mystery they have concealed so long and so successfully, but the reversal of the polarities at minimum is confirmed beyond a doubt, though the full significance of the fact is not yet disclosed. Passing to the moon, we learn, not without surprise, that the total radiation from the dark markings is nearly as great as that from the bright areas, and this peculiarity strengthens the evidence drawn from occultations of stars by the moon that our satellite has little or no atmosphere. Of the planets, it appears that the radiometric magnitude of Mercury is approximately zero and that the bright side of Venus emits about 8 per cent. of planetary radiation, which changes little with change of phase. The dark side of the planet, that is, the hemisphere turned to the earth when the planet is passing between the earth and the sun, shows a large amount of radiation of long wavelength, suggesting a low temperature near freezing point. Mars emits nearly equal amounts of planetary radiation and of reflected sunlight, supporting the generally accepted theory that Mars has a rare atmosphere. Measures of radiation from the centre and

at the limb of Jupiter, show marked differences, both in amount and quality.

Very great attention has been directed to the nebulæ and clusters of stars, particular regard being paid to the outbursts of new stars and the variation in the brilliancy of some of the older members. In the great Andromeda nebulæ, one of the few visible to the naked eye, ten new and six variable stars have been discovered, showing that these masses are the seat of great activity. Some of the variables exhibit typical Cepheid characteristics, and by the observation of this class of star it is hoped to collect data for fixing a limit to the dimensions of the stellar universe, and to determine the distance of those ill-defined and irregularly shaped bodies. It is, too, among these variables that the greatest velocities in space occur. The average radial velocity for 27 of these is 87 km. per second, and one attains a velocity of 390 km. per sec.—the greatest velocity yet observed in any star. Among such a wealth of new facts many must be passed over in this brief notice, but Mira Ceti deserves a brief mention. This star has been observed for centuries, and has presented great and inexplicable irregularities, but when observed spectroscopically the spectrum exhibits a peculiar asymmetry that led Professor Joy to suspect the existence of a hitherto unnoticed companion. On searching for such an object, Dr. Aitken, of Lick, detected an object whose position agreed precisely with that indicated by the spectroscopic observations. The diameter of the brighter star is probably not less than 200 times that of our sun, but observations with the interferometer have been much hindered by unfavourable atmospheric conditions.

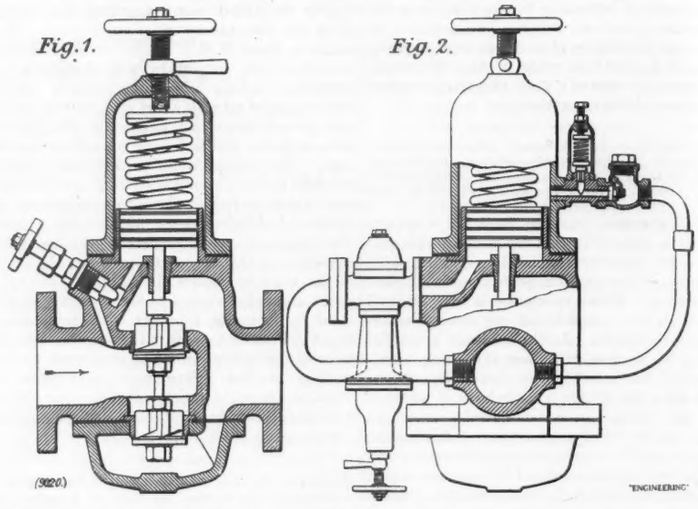
Similar unfavourable atmospheric conditions, due mainly to smoke from forest fires, have interfered with the programme for determining the velocity of light. A new powerful arc lamp, designed by Mr. Sperry, has been installed, and tests show that with this source of illumination, observations can be carried on without interruption. In the modified form of the Foucault method employed, the accurate measurement of the speed of the rotating mirror is of the utmost importance, and the design and construction of apparatus for this purpose is occupying the attention of Dr. Michelson.

Another enquiry of great interest is the variation in the spectrum of the light occasioned by an electrically exploded wire during the very brief interval the phenomenon lasts. When a condenser is used, giving a maximum discharge of 40,000 amperes at 55,000 volts, the temperature of the vapour will rise to more than 20,000 deg. C., and the light from the exploded wire is bright enough to yield fully exposed spectrograms under very extreme conditions. The width of the spectrogram is half a millimeter and it has been found possible to move this narrow spectrum over a photographic film with a speed of 500 m. a second. The spectrum moves through its own width in a millionth of a second, and the changes taking place in that short interval can be studied. At the beginning of the explosion, the spectrum is continuous, with the arc lines of the metal exploded appearing as absorption lines, and the general conclusion from the whole enquiry is, that metallic vapours at a pressure only slightly above one atmosphere emit essentially as a black body.

Model Experiments on the Bristol Fighter Aeroplane.—The utility of model work in aerodynamics depends upon comparison tests between the model and the full-scale aeroplane. From the nature of the full-scale work it is clearly impossible to test a large number of aeroplanes, and accordingly some particular aeroplane is chosen every few years for careful comparative work on the two lines. A summary of comparisons so made is given in the report of the Design Panel (R. and M. 900) on the scale effect on lift, drag and centre of pressure of complete aeroplanes and an earlier report of the Scale Effect Sub-Committee (R. and M. 374). Further work is being conducted on the Bristol Fighter aeroplane, both full-scale and model, and Reports and Memoranda, No. 937, now obtainable from H.M. Stationery Office, price 1s. net, relates to this work. The report, which is entitled "Measurements of Lift, Drag and Pitching Moment on the 1/5th scale Model of the Bristol Fighter with Airscrew Running," by E. F. Relf, A.R.C.Sc. and L. J. Jones, is a continuation of the work described in an earlier paper (Reports and Memoranda No. 876) which presented the results of measurement of lift, drag and pitching moment on the Bristol Fighter at angles below the stall. In those experiments, the airscrew was not present, except in one series of measurements, which was made with the airscrew stationary for direct comparison with gliding tests at the Royal Aircraft Establishment. The tests of the present report include lift, drag and pitching moment with airscrew stationary, at angles above the stall; similar measurements at all angles of incidence from 0 deg. to 36 deg. with airscrew running at various values of V/nD, with various tail and elevator settings, and without tail; torque measurements on the airscrew; and thrust and torque of airscrew alone, with a "minimum body" to enclose the motor. The results are mainly given as tables, but a few have been plotted.

THE THERMODIN REDUCING VALVE.

MESSRS. G. DIKKERS AND CO., HENGELO, HOLLAND.



THE THERMODIN REDUCING VALVE.

As a result of difficulties in obtaining a steady flow of steam in large plants with some forms of reducing valve, Messrs. G. Dikkers and Co. of Hengelo, Holland, who are represented in this country by G. Dikkers and Co. (England), Limited, Effingham House, Arundel-street, London, W.C.2, have designed and marketed a new type of valve which we illustrate in Figs. 1 and 2, above. With this valve it is claimed that a considerable variation in steam consumption can take place without appreciable variation in pressure, and that, at the same time, this valve, known as the Thermodin, will respond to very small pressure differences.

As will be seen from the figures, the spring loaded valve spindle carries a piston working in a short cylinder barrel at the top, and a double-beat valve of the usual type at the bottom. The degree of compression in the spring can be regulated by the hand-wheel on the spring-adjusting screw. There is a bye-pass, regulated by the throttle valve shown on the left in Fig. 1, from the high pressure side to the space beneath the piston; and from this space the bye-pass is continued through a regulating valve, seen on the left in Fig. 2, to the low pressure side. A pipe fitted with a small safety valve and a check valve is carried from the upper side of the piston to the low pressure side of the valve box. This can be seen on the right in Fig. 2.

The action of the valve is as follows: The regulating valve itself is essentially a very sensitive reducing valve of the sheet-rubber diaphragm type, and this will automatically cut off the bye-pass passage when the pressure on the low pressure side rises to a pre-determined value. When this occurs, the pressure in the space under the piston will build up to that on the high pressure side at a rate controlled by the amount to which the throttle valve is opened; and as a result the double-beat valve will be held firmly on its seating. Immediately steam is drawn off on the low pressure side, the sensitive regulating valve will open and the pressure will fall in the space below the piston. When this occurs, the double-beat valve is opened by the spring, allowing steam to pass directly from the high pressure to the low pressure side. Under steady flow conditions, a state of balance will be set up between the two sides of the valve, and when this takes place the regulating valve opening will be large, and the steam flowing *via* the bye-pass will not cause a rise in pressure under the piston. Any variation in the outlet pressure, however, will at once react on the regulating valve, and as this opens and closes, the pressure under the piston will rise and fall, thus regulating the lift of the double-beat valve. It will be evident that the rate of opening and closing of the latter will depend upon the degree of spring compression and on the amount of opening of the throttle valve, and it is claimed that, by suitable adjustment of these two elements, fluctuations on the low pressure side can be avoided, even though the alterations in steam consumption are large and sudden.

The pressure under the piston ranges from that on the high to that on the low pressure side of the valve, according to whether the regulating valve is opened or closed, and a difference in pressure between these two limits is therefore available for controlling the double-beat valve. In consequence of this, ample power is available for overcoming the piston and other frictional resistances. In the ordinary type of reducing valve in which only the difference between the required reduced pressure and the actual low pressure constitutes the regulating force, the frictional resistance of the various parts is a frequent cause of hunting, but it will be clear that this defect is avoided by the method of construction adopted in the Thermodin valve. A further advantage resulting from the ample regulating force available is that when required for use with superheated steam, it is practicable to utilise a spring mounted outside the casing with a packed gland on the spindle, so that the spring cannot be affected detrimentally by the high temperature. The friction of the packing renders this arrangement impracticable with the usual type of valve. The safety valve on the outlet pipe above the piston serves as a protection against an undue pressure rise above the piston from any cause, and the check valve prevents irregularities when starting up the apparatus. In cases where the difference between the high and reduced pressures is very small, but steam is available from some external source at a pressure higher than that on the inlet side of the valve, provision can be made for connecting the high pressure steam to the bye-pass pipe above the throttle valve. If a stop valve is introduced into this connection, and the throttle valve is closed up completely, the reducing valve will function in the same way as when there is a large pressure difference between the inlet and outlet.

The valves can be supplied with a cast-iron body and bronze working parts for use with saturated steam; or with cast-steel body and nickel working parts for superheated steam. In the latter case models are available with either inside or outside springs.

SELF-CONTAINED HORIZONTAL MILLING MACHINE.

A development finding favour in the United States, with a view to reducing the floor space occupied in the case of motor-driven tools, provides for the accommodation of the motor inside the base of the machine itself. The Brown and Sharpe Manufacturing Company, of Providence, Rhode Island, U.S.A., have recently introduced a series of horizontal milling machines of this class, driven by a motor, enclosed in an oil-tight compartment in the base of the machine itself. The series, for which the agents in this country are Messrs. Buck and Hickman, Limited, of 2, 4 and 6, Whitechapel-road, London, E.1, consists of three sizes of universal and three sizes of plain machines. The compact nature of the unit resulting from this method of construction will be clear from Figs. 1 to 3, on the opposite page, in which we illustrate the intermediate size of universal machine. A comparison of these figures with those which we gave in our issue of April 22, 1921, when dealing with a machine of the ordinary type manufactured by the same firm shows that the new design does not differ materially from the firm's standard method of construction in respects other than those necessary to incorporate the self-contained drive. As the general features of the machine were fully dealt with in our previous article, we will confine our description to the modifications resulting from the new type of drive. The important change comprises a re-design

SELF-CONTAINED HORIZONTAL MILLING MACHINE.

CONSTRUCTED BY THE BROWN AND SHARPE MANUFACTURING COMPANY, ENGINEERS, PROVIDENCE, RHODE ISLAND, U.S.A.

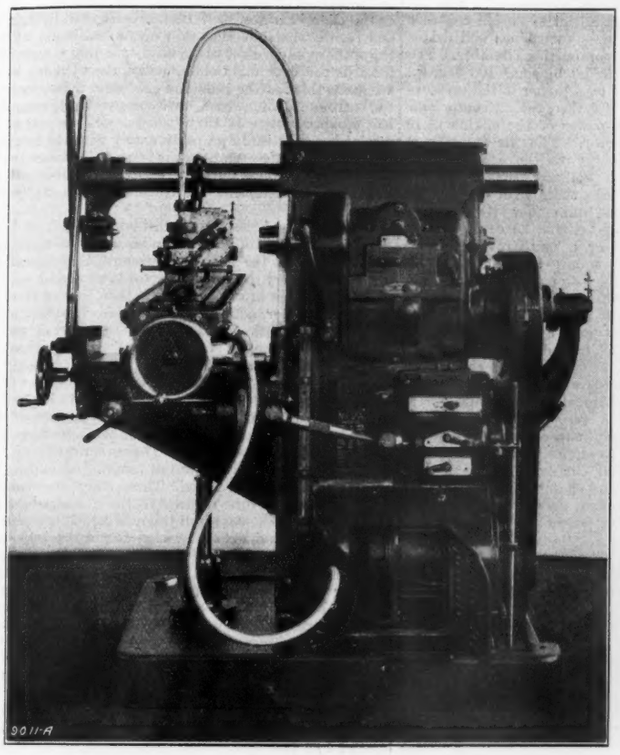


FIG. 1.

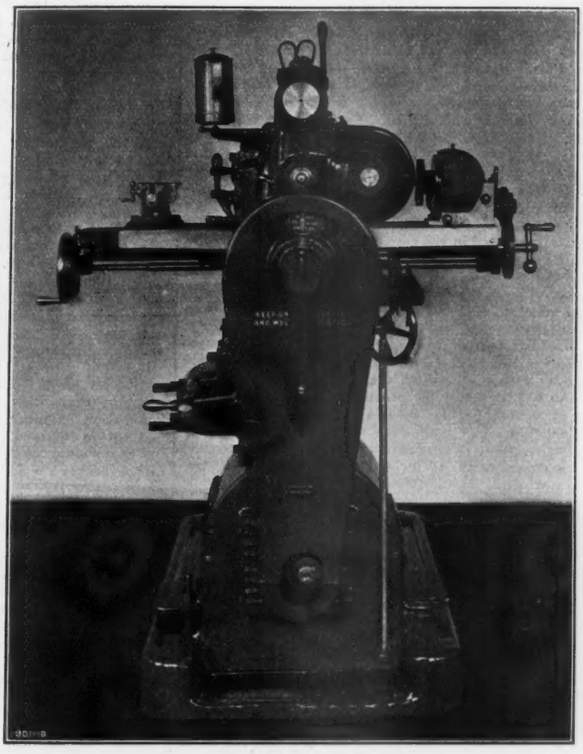


FIG. 2.

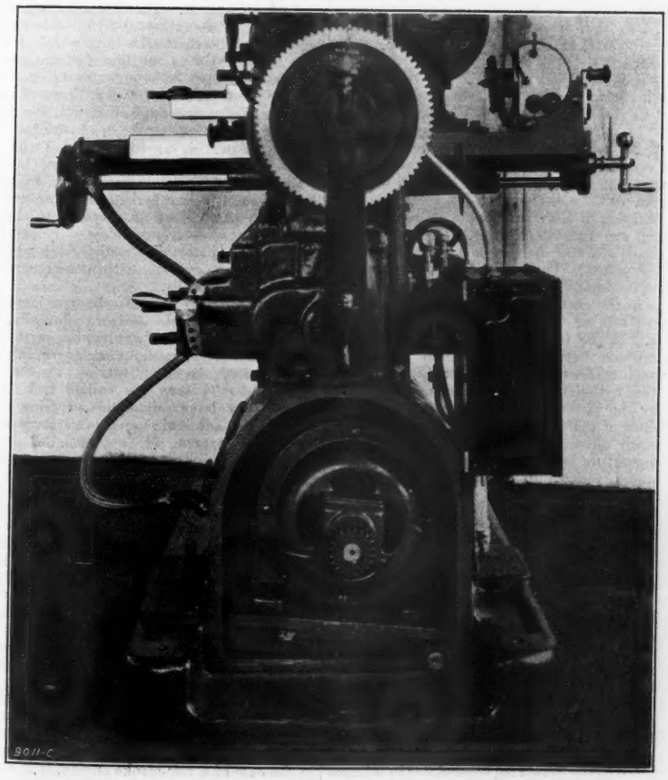


FIG. 3.

of the lower part of the column to provide for the motor compartment, which is cast with a solid top as a part of the column. It will be observed from the figures that the motor is totally encased, thus providing complete protection from oil, cutting lubricant, chips, and dirt. A tank for the cutting compound is located in the base, extending around the foot of the elevating screw, and strainers are provided in the top of the base.

Ventilators, which can be seen in Figs. 1 and 2, are provided on the sides and rear of the motor compartment, and these are made in the form of doors to permit of access for any necessary attention to the motor. The motor bearings are lubricated from oil wells fastened to the frame of the motor.

In order to facilitate the installation and removal of the motor, and to provide for adjustment of the driving chain, a separate adjustable base is provided on which the motor is mounted. As can be seen from Fig. 3, this base is hinged on the right-hand side, and has an angular adjustment regulated by means of the bolt on the left of the column outside the compartment. The bed of the motor is tongued, and slides in a groove in the hinged base. When in position the motor is held firmly in place by means of a gib inserted in the motor-ways, as seen in Figs. 3.

The machine is provided with a friction clutch, which is mounted within the sprocket on the main drive shaft. The clutch can be readily adjusted without dismantling the machine by removing the small plate on the side of the sprocket, which can be seen in Fig. 2. An opening in the chain guard is provided for the purpose of making this adjustment, so that it is not necessary to remove the guard. As will be seen from the figures, the guard fully encloses the driven and driving sprockets, as well as the chain. Complete access to the motor compartment is obtained by removing the chain guard, chain, and actual wall of the compartment.

The machine can be supplied with either chain or belt drive from the motor, and can readily be converted to an ordinary belt-driven machine, if required. In the latter case the motor compartment becomes available for storage of tools and parts. The largest size of plain machine is regularly supplied with a pump, the remainder of the machines being arranged to accommodate this fitting when required.

HEAVY-OIL ENGINES.

*Heavy-Oil Engines: Some Outstanding Questions Relating to Large Engines of the Self-Ignition Type.**

By Captain H. RIALL SANKEY, C.B., C.B.E., R.E., M.Inst.C.E.

MANY fruitful years of development of the internal-combustion engine have elapsed since Sir Dugald Clerk delivered the twelfth "James Forrest" lecture in 1904, entitled "Internal-Combustion Motors." This development has been most striking in the case of the petrol engine for motor vehicles and aircraft, and of the heavy-oil engine. But the advance in the case of the large gas engine has been comparatively small, as even in 1906 an Oechelhauser gas engine had been built developing 1,500 h.p. in a single cylinder of 43·3 in. diameter. The technical difficulties experienced 20 years ago in large gas engines from high cylinder temperatures combined with high pressures, are much intensified in the case of large heavy-oil engines by the higher pressures, and in their case it cannot be said that these difficulties have been completely overcome. The heavy-oil engine has also to contend with fuel-injection difficulties, resulting in imperfect combustion and sometimes in so-called "detonation."

Broadly, temperature difficulties do not arise with cylinders less than 18 in. diameter, but they increase rapidly with size, so that a cylinder of 33 in. diameter is the largest so far in commercial work, although an experimental engine with a cylinder of 39·39 in. (1,000 mm.) was built even as far back as 1914 by Sulzer's, and it is understood that, at present, engines with cylinders of 43 in. are in contemplation. Gas engines with 50-in. cylinders have been built. At the present day, marine practice offers the best field for large heavy-oil engines. The greatest power on one shaft, at present, is 3,000 brake horse-power, and the largest total in one ship (the Aorangi) is 13,500 brake horse-power, though ships with 20,000 brake horse-power are building. The present trend of design is towards a double-acting two-stroke engine capable of doing the same work with fewer cylinders and with equally good turning moment.

Definition of "Heavy-oil Engine."—One of the "outstanding questions" is the definition of the expression "heavy-oil engine." I will confine myself to those "heavy-oil engines" that, working either on the two-stroke or the four-stroke cycle, compress air to a temperature sufficient for the self-ignition of an injected fuel of not less than 0·82 specific gravity.

Fuel Injection.—In these engines, the fuel is injected into hot compressed air a little before the top of the stroke, and, in most cases, only a small increase of pressure above that of compression takes place on combustion, because the phenomenon is that of rapid burning as distinct from explosion. In the Beau-de-Rochas constant-volume (so-called "Otto") cycle, explosion takes place from the fact that each molecule of oxygen is within easy reach of the fuel molecule with which it is to combine. Such an arrangement of molecules must be avoided in a heavy-oil engine working at high compression, as an explosion would cause undue pressure, a matter which will be discussed later. At the same time, each molecule of the injected fuel must reach an oxygen molecule in a very short time—the order being from $\frac{1}{15}$ second to $\frac{1}{60}$ second, according to the engine speed. It will be appreciated that this is no easy problem. The rate of combustion is largely regulated by the size of the oil particles produced by the atomisation. Preferably, all the particles should be of medium size; larger particles take much longer to burn, and from want of oxygen may burn with a smoky flame. The particles may however, be too small, and they will then lack penetrative power in the dense air of a pressure of about 500 lb. per square inch—at any rate, in the case of mechanical injection. It can be shown that a particle of oil 0·004 in. in diameter, starting with a velocity of 500 ft. per second, would have its velocity reduced to 3·5 ft. per second in travelling 0·35 ft., whereas if 0·0002 in. in diameter, the same reduction in velocity would occur in travelling only 0·05 ft.

It follows from the above that, instead of completing the atomisation of the oil as it issues from the "atomiser," it should issue in a number of compact threads directed to different parts of the combustion chamber to break up into a cloud before reaching a metallic surface. Such an arrangement, combined with adequate turbulence, would ensure each molecule of oil reaching the necessary oxygen to produce a sufficiently rapid combustion. Some experiments are recorded in which, by spraying in the open with a pressure of 4,000 lb. per square inch, fine "needles" of oil were produced which passed through a flame without being ignited. At a little distance, the "needles" began to look "fluffy," and then expanded into a cloud which floated away. This cloud ignited with a "smack," producing a large sheet of flame. In compressed air, the "needles" would undoubtedly break up more rapidly. As is well known, there are two methods of injecting oil, namely, air injection and mechanical injection (also called solid injection). The former has the disadvantage of requiring an air compressor, but introduces oxygen with the oil, producing probably a small initial explosion together with an air blast which causes turbulence and drives the oil into all parts of the combustion chamber. The expansion of the air cools the jet by some 100 deg. F., which has to be allowed for by a higher initial pressure of the air in the cylinder. Further, the air compressor reduces the effective horse-power of the engine more than the mechanical injector. The air injector is able to impart greater energy to the atomised oil, to which is probably due the fact that a greater i.m.e.p. is possible with air than with mechanical injection. Thus Engineer-Commander Hawkes has found that with a high-speed engine he could obtain, with either a four-stroke or a two-stroke opposed-piston engine, 130 lb. per square inch i.m.e.p. with air injection, and only 100 lb. with mechanical injection, using Texas oil fuel in both cases. The cooling effect of air injection is especially noticeable at light loads, and may cause missfires and explosion pressures, mechanical injection is much freer from these troubles.

It would appear that, at present, the economical results per indicated horse-power are better with air injection than with mechanical. The shape of the combustion chamber has a very great effect on the combustion obtained. Many shapes have been devised, and care should be taken to obviate pockets or narrow spaces between cold metal surfaces. Some makers adopt a secondary combustion chamber in which a small portion of the oil is exploded, driving the remainder into the combustion chamber proper and producing good distribution and turbulence. Many other difficulties arise in connection with oil injection, but time will not permit of dwelling further on the subject. The more nearly perfect combustion is attained early in the stroke, the better will be the oil consumption of the engine. Departure from perfect combustion is probably the main cause of the difference of oil consumption of various types of engines per indicated horse-power, and it is interesting to estimate—if only approximately—what would be the oil consumption if the combustion were perfect.

In the ideally perfect "constant-pressure admission, constant-volume exhaust" engine it may be taken that, with a 13 to 1 compression ratio 51 per cent. of the heat due to combustion is rejected in the exhaust and there are no losses. Estimating the unavoidable losses in an actual engine as 10 per cent., the efficiency ratio would be 90 per cent. with perfect combustion. To take a numerical example, assume a fuel oil of 19,500 B.Th.U. per lb. gross value, then the heat convertible into work in the cylinder is 19,500 $(1 - 0{\cdot}51) = 9{,}555$ B.Th.U. per lb. Hence the oil consumption per indicated horse-power with perfect combustion and an efficiency ratio of 90 per cent. would be 0·296 lb. per hour. With a brake efficiency of 75 per cent., which is normal with a four-stroke engine, the oil consumption per brake horse-power would be 0·395 lb. per hour.

Temperature Stresses.—The high-temperatures and pressures occurring in heavy-oil-engine cylinders cause stresses which are difficult to meet. The parts principally affected are the cylinder-head, the cylinder-walls, and the piston. The cylinder-head of the four-stroke engine presents special difficulties because of the complication in the casting due to the necessary provision for three sets of valves, *i.e.*, fuel, air-admission, and exhaust. In the two-stroke engine, provision for the fuel-admission valve only is needed as a rule, although some makers prefer to put the scavenge valves in the cylinder-head and use exhaust-ports uncovered by the piston at the bottom of the stroke. Much difference of opinion exists on this point, and it is an important outstanding question. A subsidiary effect of temperature is to cause deposit of lime from the jacket water, which hinders the transfer of heat; this adds to the difficulty of designing cylinder-heads.

As might be expected, there is much diversity in the design of cylinder-heads for four-cycle engines. Although special grey cast-iron is sometimes used for cylinder-heads, cast steel is generally employed because the same strength can be obtained with much thinner walls, which reduces the temperature stresses. In a recent design, the Fraser and Chalmers Engineering Works have adopted a solid 4-in. thick steel disc as a cylinder-head. Another design is that of Messrs. Worthington, in which the cylinder is of steel continued as a hemispherical top to form the combustion-chamber; there is, therefore, no joint between the cylinder and the cylinder-head. The effect of temperature on the cylinder is the next matter to consider; its walls are exposed to the usual ring tension due to internal pressure and also to temperature stresses. The pressure, and consequently the ring tension, is of a fluctuating character varying from a maximum to nothing. In the case of large cylinders with thick walls, the temperature stresses exceed the ring stress, and if the temperature-gradient is considerable, the total stress can exceed the elastic limit. The temperature stresses, which are compressive at the combustion surface and tensile at the jacket surface, have been investigated by Lorenz and Lamb, who show that they are a maximum at the top of the cylinder close to the head, and diminish rapidly towards the bottom. Consequently, the cylinder walls are made thick at the head and gradually taper towards the bottom. A point which, until comparatively recently, has escaped notice is that, whereas the ring tension diminishes practically proportionately with the increase of thickness, the temperature stress increases with increase of thickness; so that with large cylinders little is gained by increasing the thickness of the cylinder-walls.

A method of obviating this difficulty has been devised by Mr. Still; the cylinder-walls are thin, but are ribbed, and the necessary strength is obtained by shrinking a steel ring at the top of the cylinder on the machined edges of the ribs. Another way of dealing with the matter, adopted by the Fraser and Chalmers Engineering Works, is to make the liner of steel; the greater strength of the steel allows of much thinner cylinder walls, thus reducing the temperature stresses. Messrs. Worthington have adopted for their recent design of double-acting engine, a steel cylinder, lined with cast iron. The cylinder-body consists of two steel cylinders with hemispherical ends to form the two combustion-chambers. The other ends of the steel cylinders have substantial external shoulders, on which abut cast-iron rings. These rings are clamped together, and in turn secured to the cylinder-base by heavy bolts. The cast-iron liner, in which are pierced the scavenge and exhaust ports, is pressed into each steel cylinder and held in position by them. Each half of the cylinder is free to expand. The jacket cooling water usually has a temperature of about 80 deg. F., except in the case of the Still engine, where the temperature is about 350 deg. F., being under pressure. The temperature of the metal just inside the skin in contact with the water is probably some 20 to 60 degs. higher owing to skin resistance and also to any deposit from the water. On the combustion side, the temperature at the top of the cylinder varies from about 2,000 deg. F. at combustion, to about 300 deg. F. at the end of the stroke, but owing to the heat-transfer resistance of a gas-film of about 0·003-in. thickness added to the heat resistance of the skin of the metal, the fluctuations of temperature just inside the metal on the combustion side are small, probably not exceeding 40 deg. F. There is probably no perceptible change of temperature 0·2 in. below the surface; practically, therefore, the heat gradient in the metal may be regarded as constant for any particular case. The gradient may be as much as 125 deg. F. per inch, but, for usual practice, 100 deg. F. may be taken. The above remarks are applicable whether the engine is working on the four-stroke or on the two-stroke cycle, making allowance for the fact that the heat-flow is about 1·6 times greater in the latter; but in this case, if the exhaust ports are uncovered by the piston at the bottom of the stroke, difficulties occur with the bars of these ports. They are exposed to the rush of the hot exhaust gases, and unless very carefully cooled, are liable to distortion—a distortion which wears the piston-rings unevenly, with consequent bad effects on the cylinder-walls.

The pistons are next to be considered, and temperature affects their design profoundly. Hopkinson has shown that in a gas engine with a piston of 11½ in. diameter, without water or oil cooling, the temperatures stress of tension at the outside rim amounts to 7½ tons per square inch; and thus it is that, for larger diameters, cooling arrangements have to be adopted; and even these arrangements have not—except in experimental engines—been successfully applied to pistons exceeding 33 in. in diameter. The maintenance of a flow of oil or water to the underside of the heated surface of a piston is not an easy matter. The difficulties are obviously accentuated in the case of double-acting engines and in those of the two-stroke cycle. The means of conducting the cooling fluid, either by telescopic or by articulated pipes, cannot be regarded as mechanically sound, and any leak, if oil is used, is costly, and if water is used, is detrimental by interference with the lubrication of crank-shaft and other bearings. Salt water must not be used, so that in the case of marine engines fresh water has to be carried for the purpose. Somewhat extensive arrangements have to be provided for cooling the circulating fluid, whether oil or water. Although one of the greatest difficulties with heavy-oil engines is the temperature stress due to the heat-flow to the jackets, it is remarkable how small that heat-flow is. Thus, in the case of a two-stroke engine, it is only about 0·3 B.Th.U. per stroke per I.H.P.

Supercharging.—A main engine of large power is

* James Forrest Lecture, delivered to the Institution of Civil Engineers on Tuesday, May 5, 1925. (Abridged.)

desirable to reduce the weight of and the space occupied by the engine, and is obtainable by increasing the weight of oil injected per stroke if arrangements are made for reasonably perfect combustion. This requires an increase of oxygen packed into the compression space, and is known as supercharging. Recently the method has been successfully worked in this country, in the United States of America, and by Professor Rateau, to obtain higher powers with aeroplane engines at high altitudes. It is also being adopted for motor-car engines. Other things being equal, the weight of oxygen in the compression space at the moment of oil-injection varies directly as the absolute pressure at the moment compression begins. This pressure is generally about 13 lb. per square inch; hence, if supercharged to 4 lb. per square inch above atmosphere, the increase in oxygen content would be as (14·7 + 4) to 13, an increase of 44 per cent. It has been estimated that about 50 per cent. more indicated power may be obtained by supercharging, but a deduction of 10 per cent. must be made for the power required for supercharging, leaving a net gain of 40 per cent. The provision of the supercharging plant adds to the capital cost. Supercharging can be applied to four-stroke and two-stroke engines, but is more easily applied to the latter as it can be combined with scavenging; that is to say, after the exhaust ports have been closed, the scavenge air can be blown to the desired pressure. It cannot be said that supercharging has advanced very far at present, except in two-stroke engines; but it may be expected to produce great improvements in the future. It must not be forgotten that the temperature stresses are increased.

Scavenging.—Scavenging presents a very difficult problem imperfectly solved at present. The best scavenging is obtained when the scavenge valves are placed in the cylinder-cover, but they complicate that casting. If, on the other hand, they are placed at the bottom of the stroke and uncovered by the piston, it is difficult—if not impossible—to obtain a perfect removal of the exhaust gases, even with a carefully-designed piston-head. The piston should be shaped so as to deflect the scavenge air entering at one side towards the top of the cylinder; but on the other side of the cylinder the exhaust gases are moving in the opposite direction, and the two streams intermingle. Glass models have been tried in order to obtain proper shapes for the piston head, but only with partial success. The problem is much simplified in the case of opposed pistons, as the scavenge air can be made to sweep right along the cylinder from end to end.

Scavenging and supercharging impart some difficulty in determining the ratio of compression. For satisfactory self-ignition, the temperature at the end of compression must be regulated, but the calculations to this end are not altogether satisfactory.

Explosion Pressure ("*Detonation*").—At one time the statement that "detonation"—or rather explosion pressure as it should be called—occurred in heavy oil-engine cylinders was greatly resented, but it is now generally accepted, and with its acceptance means for removing, or at any rate reducing, its effects are being proposed. Detonation is not the right word to use in this case, because what really occurs is an explosion of the same nature as happens in an explosion internal-combustion engine (constant-volume cycle), but the pressure reached is much higher. In a heavy-oil engine working under the cycle of constant-pressure admission, and constant-volume exhaust, a leaky fuel-admission valve, or a missfire, or too good a mingling of the fuel with the oxygen, coupled with too early ignition, may lead to an explosion, and the heat-admission may take place at constant volume. In the latter case, and with a compression-ratio of 13 to 1, the maximum pressure may be more than 1,300 lb. per square inch, even with a "mixture-strength" of only 45 B.Th.U. per cubic foot. With a heavy leak the maximum "mixture-strength" may be reached, and then the explosion-pressure may be as much as 4,000 lb. per square inch. It is not likely in practice that leakage or misfire will produce a perfect explosive mixture, so that the extreme pressures indicated above are not likely to occur; but very high pressures are reached and are shown on "displaced" indicator-diagrams.

It is clear that if such pressures occur frequently they will have a disintegrating effect on the engine; but in any case allowance must be made for those pressures by increasing the scantlings—especially those of piston-rods, connecting-rods and crankshaft—thus adding to the weight of the engine. In order to ensure self-ignition, the temperature must not be less than 700 deg. F. for ordinary heavy oils, practically irrespective of the pressure. If, therefore, the air is heated otherwise than by compression, a lower pressure will suffice and a lower compression can be adopted. Thus in the Still engine, the air is heated during compression by the hot jacket-water (temperature about 350 deg. F.). It is found that the compression-ratio can be reduced to 9 to 1, and the maximum explosion pressure for this ratio is about 800 lb. per square inch, a very great improvement. With an ordinary heavy-oil engine, the danger of misfire is greatest at starting owing to the cold cylinder-walls. It is probable that air-injection of fuel is more liable to cause explosion than mechanical injection.

Compounding.—The compounding of the oil-engine was early suggested and tried, but, as stated by Guldner, the result was a complete failure. Notwithstanding this result, a group of American engineers, headed by Mr. Sperry (of gyroscope fame) has been working on this subject for 30 years; and in 1918 a paper was read before the American Society of Mechanical Engineers reporting complete success with a small engine, but I have been unable to ascertain whether or not any large engine on this principle has yet been made or is even under construction. In the experimental engine, according to indicator-diagrams given (but with no scale) the compression-pressure was 550 lb. per square inch and, "detonation" being deliberately adopted, the maximum pressure reached was 1,000 lb. per square inch. The exhaust from the high-pressure cylinder takes place through a special transfer valve at about 250 lb. per square inch, and expansion to atmosphere then takes place in the low-pressure cylinder. The air-charge is compressed, first in the low-pressure, and then in the high-pressure cylinder, passing through the transfer valve and assisting to cool it. The fuel is introduced into the high-pressure cylinder by mechanical injection. The engine is single acting and works on the four-stroke cycle. The following statements are made in the paper referred to. The M.E.P. in each cylinder is 330 lb. per square inch, and, as a consequence, the weight of the engine is about one-tenth that of an ordinary engine, that is, the weight is about 30 lb. per brake horse-power. The mechanical efficiency is said to be extremely high, but the paper makes no reference to fuel consumption. It would be imagined that the transfer valve would cause much trouble, but in the discussion on the paper, Mr. Orrok stated that he had seen this valve after 2,000 hours' run, that it was in perfect condition, and that there were no signs of its having been hot.

Materials Used.—Ordinary carbon steel is generally used for crankshafts, connecting-rods and piston-rods; the specially heat-treated steels adopted in high-speed petrol engines for the sake of lightness, have not, up to the present, been largely adopted for heavy oil engines, but their use will probably be considered in the future to reduce the weight of the engine. Until recently, cast iron of special mixture has been used for cylinder-liners and pistons, but trials are now being made with forged steel for cylinder-liners and aluminium alloys for pistons. Steel castings for cylinder heads are especially suitable for two-stroke engines, the castings being comparatively simple. Steel has greater elasticity to resist deformation than cast iron. The forged steel liners used by the Fraser and Chalmers Engineering Works and Messrs. Worthington appear to be a move in the right direction; but this still requires the sanction of experience. The usual material for cylinder walls or liners is cast iron, but of a special quality, and the same may be said about pistons. Recently there was a conference on the subject by the local section of the Institution of Mechanical Engineers and the Institute of British Foundrymen at Glasgow. The consideration of this discussion leaves the impression that castings for large heavy-oil engines are an outstanding question. The weight of cast-iron pistons has led to the adoption of aluminium alloy in some cases. Such pistons are universally used in aircraft engines and in many motor-car engines, for lightness, to reduce inertia forces and thereby to make very high speeds possible. The same consideration applies to high-speed large heavy oil engines (300 r.p.m. and over), and such pistons are used for this reason by the Fraser and Chalmers Engineering Works. Engineer-Commander Hawkes has experimented with them, and states that their adoption up to a diameter of 20 in. is warranted in the Navy.

Weight.—The heavy-oil engine of to-day suffers greatly from excessive weight. In the case of land engines the disadvantage is mainly a question of cost, which approximately increases proportionately to the weight; but in the case of the marine engine, in addition to cost, there is the great objection of the additional weight to be carried and of the additional space required. It is imperative that great reduction in the weight of heavy-oil engines for marine purposes be made without undue delay, so that engines of 2,000 to 5,000 brake horse-power can compete with steam plant. Beyond the latter power, the steam turbine will undoubtedly hold the field until the oil-turbine is a practical proposition, or some marked improvement in construction is devised. The four-stroke single-acting engine is obviously the worst offender. The two-stroke engine is better because the ratio of maximum to mean pressure is approximately halved, but the best of all is the double-acting two-stroke engine in which the ratio of maximum to mean pressure approximates to that of a steam engine, and the crank-shaft is not exposed to alternating stresses, though there still remains the possibility of explosion pressure. A great reduction in weight can be effected by increasing the revolutions, but this method is, to a certain extent, denied to the marine engine on account of the propeller, which loses in efficiency as the revolutions increase. A possibility is to run the oil-engine at a high speed, say 300 r.p.m. and over, and reduce the propeller-shaft speed by helical gearing, as is done, for example, in the case of steam turbines. The method has been tried with good results.

Another cause of heavy weight at present is the comparatively small power obtainable per connecting rod, even with a double-acting engine, so that for a large engine a multiplicity of cylinders must be used. The reported success of experimental engines with cylinders of larger diameter than hitherto used is hopeful for the future.

Lubrication.—The lubrication of the cylinders and of the moving parts is of great importance, and, to-day, the amount of oil used is excessive. The tendency of lubricating oil is to carbonise, and thus produce hard deposits which jam the piston rings and score the cylinder liners. At present, the best way is to specify a particular brand of oil and to depend on the oil merchant—not a satisfactory proceeding—so that better knowledge is obviously required. What effect viscosity has is still uncertain. The places where oil is introduced into the cylinder require much care in selection, especially in two-stroke engines. Somewhere near the exhaust and air ports, that is, about midway down the cylinder, is probably best; but if care is not taken, the oil will be blown out through the exhaust ports. The apparently insignificant fact of chamfering the piston for a short distance below the scraper ring and the lower ring, and by providing at those positions relief holes to the inner side of the piston, has been shown to reduce the cylinder lubrication from 4 or 5 per cent. of the fuel oil to 1½ per cent. It is important to prevent the cylinder lubrication from dripping on to the crank-shaft bearings. It may contain carbon and fuel oil ash in a finely-divided state, which interferes with the lubrication of the journals if these are of the open type. The desire for an "open" engine expressed by the old school of marine engineers, leads to a gravity system of lubrication for slippers, connecting-rod and crankshaft bearings, and each point of lubrication requires individual and special attention. In a closed engine, forced lubrication has to be adopted, which enables each bearing to be flooded with oil, giving continuous lubrication. Thus, only the lubricating pump has to be attended to, the quality of the lubricant is under constant observation, and the oil can be cooled.

Utilisation of Waste Heat.—In the case of a gas engine, the heat in the exhaust is about 45 per cent. of the heat of combustion of the gas, and has been used in exhaust boilers which give about 2 lb. to 2·5 lb. of steam per horse-power. The heavy-oil engine has a better thermal efficiency than a gas engine, and hence there is less heat rejection. Moreover, the temperature of the exhaust is less. The amount of steam produced is small, namely, 0·8 lb. of steam for a four-stroke engine, and 0·5 lb. per horse-power for a two-stroke engine. The installation of an exhaust boiler has, therefore, except under special circumstances, no practical value when due allowance is made for capital expenditure and maintenance. A suggestion has been made to use the exhaust gases to work a gas turbine. I have recently examined a patent by C. Lorenzen which might help in this direction. The disc of the turbine is made to act as a fan and blows cool air through hollow turbine blades; the turbine is run by the exhaust gases, and the air could be used for scavenging. The air would, however, be heated in cooling the turbine blades.

So far, the exhaust gases have been considered, because the heat carried away by the jacket water is at too low a temperature to be useful to obtain power. If, however, the jacket is maintained at a high temperature, the heat therein can be added to that of the exhaust, and a considerable quantity of steam can be produced, so much so that more than 10 per cent. additional power can be obtained from the engine, if the steam is applied to the underside of the pistons of the oil engine in accordance with the Still system.

The outstanding questions referred to above are some of the more important ones; but there are many others, such as the best arrangement of cranks to obviate vibration, having due regard to uniformity of turning moment; also whether it is better to have a single fuel-pump delivering into a pipe common to all cylinders, or else a separate fuel-pump for each cylinder. For the merchant marine a low-speed engine of much greater power than is at present possible is needed, and of lighter weight per brake horse-power. This may be regarded as the most outstanding question, but before it can be answered the subsidiary problems discussed in this lecture will have to be solved satisfactorily.

60-H.P. CIRRUS ENGINE FOR LIGHT AEROPLANES.

CONSTRUCTED BY THE AIRCRAFT DISPOSAL COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 1.

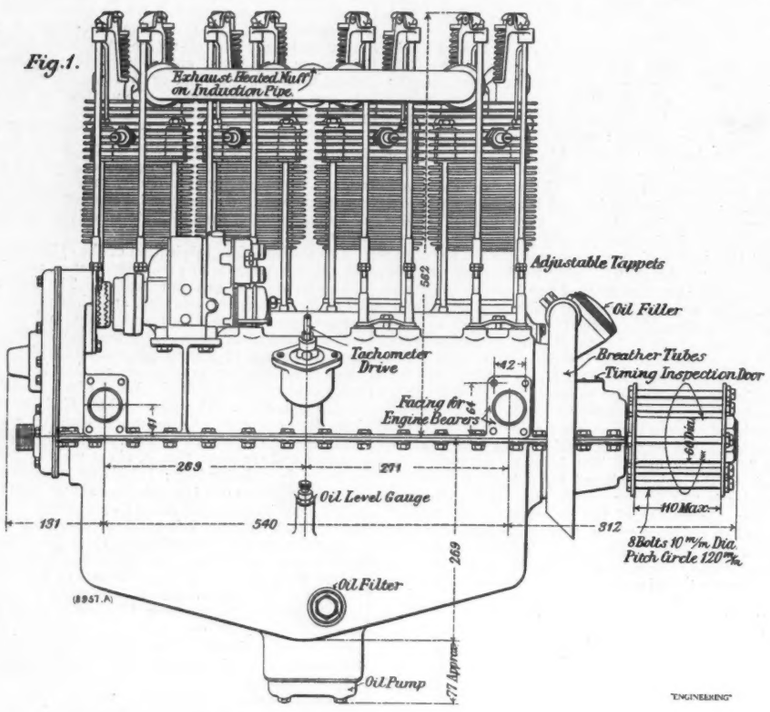
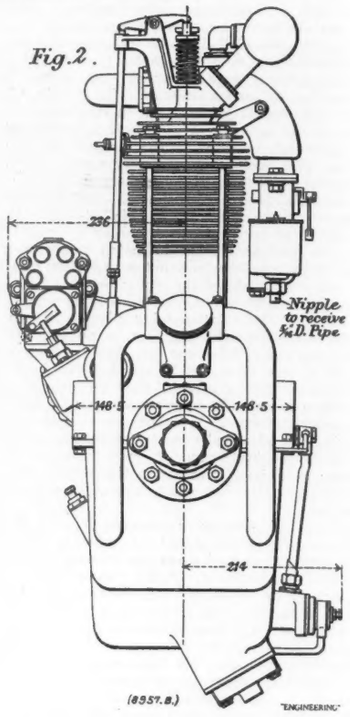


Fig. 2.



THE HUXLEY CENTENARY.

ON Monday last the authorities of the Imperial College of Science and Technology paid a tribute to the memory of Professor Thomas Henry Huxley on the centenary of his birth. The Imperial College comprises the Royal College of Science, the Royal School of Mines, and the City and Guilds (Engineering) College; and Huxley was appointed Professor of Biology at the Royal College of Science (then the Normal College) in 1854, and was Dean of the College and of the Royal School of Mines from 1881 to the time of his death in 1895. It is thus particularly fitting that the centenary of his birth should be celebrated within the walls of the College in which he carried out much of his most distinguished work, although the only part of the buildings of his day now remaining is the well-known terra-cotta block on the east side of Exhibition-road.

It may justly be said that the Imperial College itself constitutes a worthy memorial to Huxley, as it is largely devoted to the provision of training for state-aided students who show exceptional promise, a measure of which he was always a warm advocate. The authorities announce that it is proposed to make the commemoration an annual one, and the proceedings, on the first occasion, took the form of a lecture describing Huxley's work by Professor E. B. Poulton, followed by a reception in the evening by the Right Honourable Lord Buckmaster, who is Chairman of the Governing Body of the College, and by Lady Buckmaster. A number of exhibits of apparatus and processes were arranged in the laboratories of the College, and demonstrations of various kinds were given by members of the staff. The exhibits were mainly of a highly technical nature, and illustrated various lines of research which are being conducted in the College. Demonstrations were given, in some cases, by commercial firms, and amongst those of more direct engineering interest may be mentioned an exhibition of electric welding by the Quasi-Arc Company, Limited, who also showed radiographs and micrographs of various welds; a demonstration of automatic furnace-temperature control and of various instruments by the Cambridge Instrument Company, Limited; and a demonstration of the use of rescue apparatus in a smoke-laden atmosphere by Messrs. Siebe, Gorman and Co. It is not possible to deal with the numerous interesting demonstrations given by the staff of the College in any detail, but amongst the most striking of these was the shooting of quartz fibres carried out by Professor Vernon Boys; and a demonstration of the grid photophone, by means of which speech was transmitted by means of a beam of light from the floor of the Bessemer laboratory to a gallery some distance away.

THE CIRRUS AERO ENGINE.

WE illustrate on this and on the opposite pages a new aeroplane engine, known as the Cirrus, produced by the Aircraft Disposal Company, Limited, Regent House, Kingsway, W.C.2, and specially intended for use on school or privately-owned light aeroplanes. The engine, which has an R.A.C. rating of 27·3 h.p., develops 60 h.p. at its normal speed of 1,800 r.p.m., or a maximum of 65 h.p. at 2,000 r.p.m. We understand that it has been adopted for the "Moth" two-seater light aeroplane now made by the De Havilland Aircraft Company, Limited, of Stag-lane Aerodrome, Edgware, Middlesex, giving this machine a speed of 90 m.p.h. with a petrol consumption of one gallon for 20 miles.

Side and end elevations of the engine are given in Figs. 1 and 2 above, while photographic views, taken from the opposite side and end, are reproduced in Figs. 3 and 4 on the page opposite. As will be seen, the engine is of the four-cylinder, air-cooled type with the cylinders mounted on the crankcase in a single row after the manner of an ordinary motor-car engine. The cylinders, which have a bore of 105 mm. and a piston stroke of 130 mm., are of cast iron, the walls being provided with cooling fins as shown. Fig. 5 illustrates one of the cylinder heads, which are of cast aluminium alloy, four long studs passing through lugs in the heads being employed for the attachment of each cylinder unit to the crankcase. The joints between the cylinders and heads are made by copper and asbestos washers. Both valves are of the overhead type and are operated by push rods through rockers supported by brackets cast on the cylinder heads clearly shown in Fig. 5. Double-helical springs, attached to the valves by washers and cotters, are employed and the springs for both inlet and exhaust valves are interchangeable. Steel adaptors are fitted to the inlet and exhaust ports, the manifolds being attached to these by means of gland nuts; the induction pipe is fitted with an exhaust-heated muff, as indicated in Fig. 1.

Aluminium-alloy pistons, each fitted with two cast-iron rings, are employed, and the gudgeon pins, which are of hardened steel, are floating fits in the piston and are fixed by studs and nuts in the connecting rods. The latter are of H section and the big-end bearings are of white metal cast directly in the rods. The crankshaft runs in five bearings, the three inner bearings being of white metal in phosphor-bronze shells while ball bearings are fitted at each end. The propeller is mounted directly on the forward end of the crankshaft, no reduction gearing being employed so that the propeller runs at engine speed; a ball race is fitted to take the thrust. The three intermediate crankshaft bearings are carried by the upper part of the crankcase in which the camshaft is located, as also are the upper halves of the housings for the ball bearings at the ends of the crankshaft. The lower halves of the ball-bearing housings are formed in the lower part of the crankcase which also acts as the oil sump and carries the oil pump, relief valve and oil strainer. The filler cap and the pressure pipes for the lubrication system are fitted to the upper part of the crankcase in front of the cylinders at the forward end, so that they are readily accessible.

The camshaft is carried in three plain phosphor-bronze bearings, all the cams and bearing surfaces being case hardened. A spiral gear on the camshaft drives the oil pump, which is located in the lowest part of the crankcase so that it is always primed with oil. The oil is delivered through a gauze filter to passages which lead it directly to each of the main crankshaft bearings. Surplus oil which escapes from the bearings is caught by oil throwers, or banjoes, attached to the crankwebs, whence it flows by centrifugal action to the crankpins, the excess thrown off from the latter serving to lubricate the piston, gudgeon pins and other parts of the engine. Since the camshaft is exposed in the interior of the crankcase, sufficient oil is splashed on to it to lubricate the bearings, valve tappets and guides; a special jet is, however, provided near the camshaft driving gear to ensure an ample supply of oil for the lubrication of the teeth.

One carburettor, of the Zenith F.S. 42 type, is supplied and a 4-cylinder B.T.H. magneto, fitted with an impulse starter, is provided; the sparking plugs used are of the K.L.G.-F.15 type. A hand-starting gear, shown in Figs. 3 and 4, is fitted at the rear end of the engine, and by pulling a lever conveniently located in the cockpit and connected to the lever

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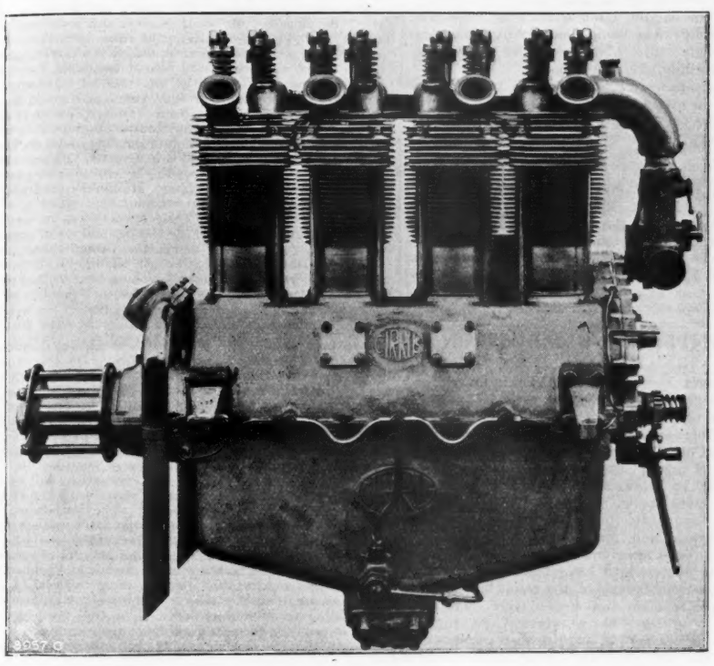

FIG. 3.

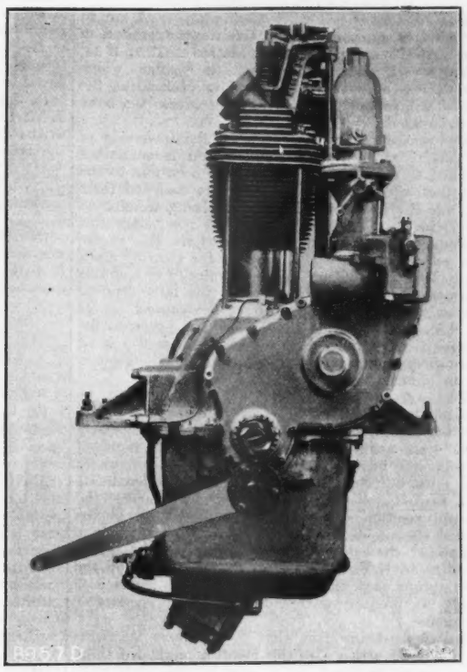

FIG. 4.

FIG. 5.

visible in the illustrations by means of a flexible cable, the pilot can start up the engine without leaving his seat. The total weight of the engine, without fuel and oil, is 260 lb., and the petrol consumption, at the normal output of 60 h.p., is given as 0·68 pint per horse-power hour. The corresponding figure for the consumption of lubricating oil is 0·02 pint per horse-power hour.

LAUNCH OF THE FERRY STEAMER "McKIE."—Messrs. Napier and Miller, Limited, of Old Kilpatrick, have recently launched the steel screw ferry steamer McKie, which is being built to the order of Messrs. McKie and Baxter, of Govan, for service on the River St. Lawrence, between Quebec and Levis. The vessel, which is being constructed to the requirements of the Bureau Veritas, is 150 ft. in length, 66 ft. 6 in. in breadth, and 16 ft. in depth, and has been specially designed for carrying motor-cars and other vehicles on the main deck and passengers on the promenade deck. The machinery is being supplied by Messrs. McKie and Baxter. A sister ship also under construction at Old Kilpatrick will be launched shortly.

ENGINEERING TRAINING AND EDUCATION.

Marine Engineering and Naval Architecture Scholarship Scheme.—Messrs. Swan, Hunter and Wigham Richardson, Limited, of Wallsend, and Messrs. Barclay, Curle and Co., Limited, of Glasgow, are offering four annual scholarships for competition among the apprentices employed by these firms or by their associated companies. The awards consist of two scholarships in naval architecture and two scholarships in marine engineering, open, respectively, to apprentices employed in the shipyards and works of the two companies, one scholarship of each class being granted in each firm. Each scholarship will be tenable for the course of study prescribed for the pass degree in naval architecture or engineering at Armstrong College, Newcastle-upon-Tyne, at the University of Glasgow, or at any other university or technical college approved by the company. In each case the company pays all class fees, gives a sum for the purpose of buying books, &c., and grants a subsistence allowance during the continuance of each academic term. During the summer vacation, a scholar must resume his apprenticeship in the works. Candidates for these scholarships must be British subjects and must not be more than 19 years of age on the first day of July preceding the qualifying examination, which is usually held about September. This examination includes as subjects English, either French, German or Latin, pure and applied mathematics, physics, mechanics, and experimental science. All candidates must have been in the employment of one of the associated companies for a year prior to the submission of their applications.

"Peake" Travelling Scholarship in Mining.—The Council of the Midland Institute of Mining Engineers have established a travelling scholarship, value 50*l.* and tenable for one year, out of funds generously provided by Major G. H. Peake. The "Peake" travelling scholarship is open to British subjects over 20 years of age who are members of the Midland Institute of Mining Engineers, who are being regularly trained as mining engineers and who have had at least one year's underground experience in a colliery. Applications in respect of the first award, to be made at an early date, must be received by the secretary of the Institute not later than June 30, 1925. Candidates will be required to submit a birth certificate and a certificate of service and good character from their employers. The successful applicant must devote not less than three months to the special study of coal mining in any district other than that in which he is being trained. Further, he must follow out a scheme of investigation to be approved by the Peake Fund Committee, and at the end of the term supply a final report, giving a general review of the results of his studies, to that committee.

TWIN-SCREW STEAMER "CONTE BIANCAMANO."

ON Thursday, April 23, Messrs. William Beardmore and Company, Limited, launched from their Naval Construction Works, at Dalmuir, the twin-screw steamer Conte Biancamano which is being built to the order of Messrs. Lloyd Sabaudo, of Genoa, Italy, for their passenger and cargo service between that country and the American continent. The vessel has an overall length of 655 ft., a breadth of 76 ft., and a depth of 48 ft., while the loaded draught will be 26 ft. The gross tonnage will be approximately 23,000 tons, the service speed 20 knots, and the full complement of passengers and crew will number 2,250. Building under special survey to the highest class of the British Corporation, the Registro Italiano and Lloyd's, the ship is subdivided throughout to the full requirements of the International Convention for the Safety of Life at Sea. A straight stem, raked forward, and a long elliptical counter stern give a good appearance to the vessel, which will have two funnels and two masts. The propelling machinery, entirely designed and constructed by the builders, consists of two sets of compound steam turbines of the Parsons impulse and reaction type, each driving a separate propeller shaft through double-reduction helical gearing. Each set is capable of developing 12,000 s.h.p., the intended service power being 21,000 s.h.p. at 95 r.p.m. of the propellers. Steam will be generated in seven double-ended and two single-ended boilers, fitted with the Wallsend-Howden oil-burning system, and operating under forced draught. Smoke tube type superheaters will be supplied, together with tangential dryers. Thermo-tank ventilation will be installed throughout the ship, together with Brown's steam steering gear, steam winches, and deck machinery. Altogether the vessel represents a marked advance on the two previous ships Conte Rosso and Conte Verde, which were constructed by Messrs. Beardmore for the same owners in 1921. The former ship was described and illustrated on pp. 198 and 223 of our issues of February 17 and 24, 1922, while an account of the trials of the Conte Verde appeared on p. 620 of our issue of May 18, 1923.

LETTERS TO THE EDITOR.

THE ACCIDENT TO THE R 33.

TO THE EDITOR OF ENGINEERING.

SIR,—While, as a former airship officer, I am in the main in agreement as to the views expressed in your article on the recent accident to H.M.A. R 33, I find myself reluctant to adopt the opinion which you express as to the undesirability of locating the control compartment of new airships within the bows of the vessels.

The present control position on the underside of the craft, which "die-hard" opinion is somewhat inclined to regard as sacrosanct, has been due to the fact that when existing airships were designed there was no alternative to their flights being terminated otherwise than on the ground; but now, since this procedure has been rendered, due to the size of the new vessels and the development of the mooring mast, both physically difficult and economically undesirable (because of the heavy expense of the large landing parties required), the location of the control car as on H.M.A. R 33 has no advantages, and possesses the severe disadvantage that it creates parasitic head resistance due to the turbulence which it engenders in its wake.

The search for an alternative position must be guided by three main considerations—the place selected must allow the pilot good vision, particularly when approaching the mooring mast; it should, if possible, not increase the head resistance of the vessel; and must not entail any appreciable reduction in its gas capacity—desiderata satisfied by placing the control position within the streamline form of the hull at its bow extremity.

Against the adoption of this proposal the recent accident to H.M.A. R.33 is cited, presumably on the assumption that the present system of mooring is likely to produce a repetition of such regrettable incidents.

In view of the fact that four serious accidents have already arisen with this mooring method, I think there would be much to be said for this contention were it not for the fact that the advocates of the bow control position are strongly opposed to the present catastrophic system, and urge that rigid airships should be secured to a mast with a two-armed rotating head by attachments on either side of the vessel located on a main transverse frame well aft of the extreme bow.

I do not presume to indulge in a technical dissertation (which must of necessity be of considerable length) on the mechanical and structural advantages of this proposal; actual trial must naturally determine the measure of its success, but since the scheme is closely analogous to the Masterman non-rigid mooring method, which has been successfully employed in this country, and has been adopted both in the United States and Japan, there would appear to be fair promise of success, and with that success a complete justification of the advocates of the bow control position.

I am, Sir, yours faithfully,
P. L. TEED, Major (late R.A.F.).
Hayesden House, near Tonbridge, Kent,
April 29, 1925.

THE LYTHAM RAILWAY ACCIDENT.

TO THE EDITOR OF ENGINEERING.

SIR,—I note with considerable interest in your issue of ENGINEERING of April 24 last, Colonel Sir J. W. Pringle's report on the Lytham Railway Accident, which would lead the ordinary person to believe that if anything goes wrong with the leading wheels of an engine fitted with a bogie, all the remaining parts of the engine are bound to follow the course or direction of the faulty leading wheel.

His idea may work well in theory, but in practice it is another matter. I have done some 2,000,000 miles on the footplate of locomotives in England and several other parts of this world, and had many incidents of interest during that period, one of which I will quote that causes me to disagree with Colonel Pringle's findings.

Some seven years ago I was working the daily express from Malacca in the Straits Settlements to Kuala Lumpur, the Federal capital in the Malay States, 98 miles, with an engine of the 4-6-2 type weighing, in working order, 85 tons. When about half the distance had been completed and doing some 35 miles per hour, we noticed a sort of grinding, yet the engine was running fairly steady. On looking over the side, I could see ballast being displaced; we had two firemen—first and second. The first fireman immediately got down on the engine steps. I inquired what was wrong. He said he could not see anything wrong. On getting on the steps myself, I could see that the leading wheel was off the rail, and appeared to be carrying no weight. Looking forward about 50 yards in front was an open girder bridge.

It was too late to attempt to stop, and I decided to trust to luck and stick tight, which we all did.

The derailed wheels went over the bridge with ease, so we stopped as soon as we could after getting over. Before lifting the engine, I found that the front part of the bogie frame was being held up by the cotter through the bogie centre-pin, the weight being transferred to the trailing axle of the bogie.

In the circumstances, I cannot agree with Colonel J. W. Pringle in attributing the cause of the accident to the defective tyre on one of the leading wheels of the bogie.

Faithfully yours,
J. MOSCROP.

Station-road, Port St. Mary, Isle of Man,
May 3, 1925.

[NOTE—We reproduce the above communication as a record of an interesting experience, but hardly think it disproves the main conclusion of the report in question.—Ed. E.]

THE INTERNAL-COMBUSTION TURBINE.

TO THE EDITOR OF ENGINEERING.

SIR,—I observe in your leading article of May 1, that the best figure so far reached (and that in the case of the Holzwarth turbine) is recorded as 14 per cent., reckoned on the basis of shaft-horse-power.

Having been deeply interested in this matter for the last 12 or 14 years, and watched as closely as possible the development of the Holzwarth turbine, and being consequently privy to all the tests and practical progress which have been made, I should like to correct the above apparent misapprehension.

In numerous tests which have been done with the internal-combustion oil turbine, the result has been between 16·17 per cent. on shaft-horse-power. The same remarks apply to the 700-kw. vertical gas turbine. This indeed is explained in Mr. Koenig's paper immediately after the data given for certain tests. Perhaps it would be in place to add that a cast-iron and steel model of the Holzwarth turbine (a perfect representation) is in this office, and can be seen by anyone interested in it.

Yours faithfully,
ARTHUR H. LYMN.

40, Westminster-Palace Gardens, London, S.W.1.,
May 4, 1925.

BOOKS RECEIVED.

United States Department of the Interior. Forty-fifth Annual Report of the Director of the Geological Survey to the Secretary of the Interior for Fiscal Year ended June 30, 1924. Washington: Government Printing Office.

United States Geological Survey. Bulletin No. 750—G. *Bauxite in North Eastern Mississippi.* By E. F. BURCHARD. No. 751—D. *Geologic Structure of San Juan Canyon and Adjacent Country, Utah.* By H. D. MISER. No. 751—F. *The Ekalaka Lignite Field, South Eastern Montana.* By C. M. BAUER. No. 751—G. *Geology and Oil and Gas Prospects of Part of Moffat County, Colorado, and Southern Sweetwater County, Wyoming.* By J. D. SEARS. [Price 20 cents.] No. 753. *Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, California.* By W. S. W. KEW. [Price 50 cents.] No. 760—B. *The Physical Features of Central Massachusetts.* By W. C. ALDEN. No. 761. *Molybdenum Deposits. A Short Review.* By F. L. HESS. [Price 15 cents.] No. 762. *Geology and Ore Deposits of the Rochester District, Nevada.* By A. KNOPF. [Price 15 cents.] No. 765. *Geology of the Region around Lead, South Dakota, and its Bearing on the Homestead Ore Body.* By S. PAGE. [Price 20 cents.] Washington: Government Printing Office.

The Principles of Thermodynamics. By GEORGE BIRTWISTLE. Cambridge: University Press. [Price 7*s.* 6*d.* net.]

Electricity for Everybody. By R. BORLASE MATTHEWS. Third edition, revised. London: The Electrical Press, Limited. [Price 7*s.* 6*d.* net.]

Forschungsarbeiten auf dem Gebiete des Ingenieurwesens. No. 273.—*Die Bestimmung der Zahigkeit des Wasserdampfes.* By Dr.-Ing. H. SPEYERER. Berlin: V. D. I. Verlag G.M.B.H. [Price 5 marks.]

Cast-Iron. By Colonel Jean Rouelle. Translated by ALFRED CHAPPLE, M.A., B.Sc. London: Geoffrey Bles. [Price 5*s.* net.]

Steel. By Colonel Jean Rouelle. Translated by ALFRED CHAPPLE, M.A., B.Sc. London: Geoffrey Bles. [Price 5*s.* net.]

United States Geological Survey. Bulletin No. 769. *The Geologic Time Classification of the United States Geological Survey compared with other Classifications, accompanied by the original Definitions of Era, Period and Epoch Terms.* By M. G. WILMARTH. Washington: Government Printing Office. [Price 20 cents.

Industrial Courts Act, 1919. Report by a Court of Inquiry concerning Steel Houses. London: His Majesty's Stationery Office. [Price 4*d.* net.]

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Shells and Armour.—One of the most interesting developments of the week is Sir Robert Hadfield's announcement of the success of his firm, Messrs. Hadfield Limited, in securing contracts for armour-piercing projectiles and thin armour. The shells, which are for the British Service, are of 16-in. calibre, and represent the latest type. The first delivery of these projectiles has passed under test and been accepted by the Government. Details of the test are not, of course, available, but it is permissible to state that it was one of unexampled severity, and only three or four years ago would have been thought impossible to fulfil. Only a few days ago another test, representing the results of much research and skill as well as efficient manufacturing methods, took place on a quantity of special thin armour. Plates taken at random passed an exceedingly severe acceptance test, and the whole lot of Messrs. Hadfield's products of this description being taken without the rejection of a single pound of material. This contract was secured in face of competition from all the leading makers of armour in this country, France, Austria, the United States, and elsewhere. In the original trial test, the Sheffield armour was found to be the best, and everything done in an experimental way was later repeated in actual practice with entire satisfaction. Hopes are entertained of the receipt of other contracts of this description in the early future.

Iron and Steel.—The position in the heavy branches does not improve. In some sections conditions are definitely worse than at the beginning of the year. Inquiries for basic steel have fallen off substantially, and only a proportion of available plant is in operation at prices which, considered by themselves, are barely remunerative. When the upkeep of idle plant has to be taken into account, the bulk of the work in hand allows no return on invested capital. Many open-hearth furnaces are standing. In pig iron, hematite, and scrap, transactions all the way round are strictly limited to the meeting of current requirements. The withdrawal of official minimum prices in partly manufactured steel by makers in other districts has not affected the local control over billet production. There is a fair amount of business passing in steel sheets, but makers of rods and cold-rolled strip could comfortably handle more orders. Light foundries are doing moderately well mainly in the meeting of building trade requirements. The tool branches are busy in patches, farm and garden implements and excavating tools representing two of the most active lines.

South Yorkshire Coal Trade.—From the standpoint of production, the position has improved as compared with a week ago. More house coal of best quality is going away to London and the country districts, but the position, so far as forward contracts are concerned, is unsatisfactory. This is reflected in the failure of Derbyshire collieries to maintain maximum prices. Derbyshire best brights have this week declined an average of 1*s.*, Derbyshire best house coal an average of 6*d.*, and Derbyshire best large nuts an average of 2*s.* per ton. Best steams are in fair demand on home account, mainly at unaltered rates, but the weakness of the export market, arising largely from foreign underquoting, is responsible for the offer of substantially lower prices than obtain for home consumption. Cobbles and slacks show no new feature. Quotations: Best branch handpicked, 30*s.* to 33*s.*; Barnsley best silkstone, 26*s.* to 27*s.*; Derbyshire best brights, 26*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* 6*d.* to 25*s.* 6*d.*; Derbyshire best large nuts, 18*s.* to 22*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; smalls, 3*s.* 6*d.* to 5*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is slightly more business passing in Cleveland pig-iron, both on home and export account, but transactions are still on a very limited scale. Confidence in the future is still lacking, with the result that disinclination to operate, beyond making provision for early requirements, continues marked. Thus sales are almost entirely confined to transactions in small lots to meet pressing needs. No. 3 g.m.b. has been sold for export at 77*s.* f.o.b., and this may be regarded as the market quotation, though customers claim they can shade the figure and report business for home use at 76*s.* No. 1 is 82*s.*; No. 4 foundry, 76*s.*; and No. 4 forge, 75*s.*

Hematite.—East-Coast hematite is plentiful. In this branch also there is just a little more doing on home and overseas account. Producers are keen to reduce their stocks. Nos. 1, 2 and 3 are on sale at 81*s.* 6*d.*, and No. 1 is quoted 82*s.*

Foreign Ore.—Foreign ore is without new feature. In the continued absence of transactions, sellers still base market rates on best rubio at 22*s.*, c.i.f. Tees.

Blast Furnace Coke.—Durham blast-furnace coke, of good average quality, is on sale at 22*s.*, delivered to local users.

Imports of Iron and Steel.—The monthly statistics of the Tees Conservancy Commission, issued this week, give the imports of iron and steel to the River Tees from Holland, Belgium, France, Norway, Sweden, Germany, India and coastwise for the six months ended April 30 last, together with the figures for the same months a year ago, and for the corresponding pre-war period of 1913–14. Pig-iron imported in the past six months amounted to 6,891 tons, as compared with 13,707 tons a year ago, and 106 tons in the pre-war

period; crude sheet bars, billets, blooms and slabs brought in up to the end of last month reached 68,639 tons, as compared with 36,972 tons a year ago, and 24,134 tons in the pre-war period; and plates, bars, angles, rails, sheets, and joists unloaded in the past six months totalled 12,939 tons, as compared with 8,286 tons a year ago, and 13,406 tons in the pre-war period.

Shipments of Iron and Steel.—April shipments of iron and steel from the Tees amounted to 78,041 tons, comprising 30,635 tons of pig-iron, 7,672 tons of manufactured iron, and 39,734 tons of steel. Of the pig-iron cleared 15,219 tons went to foreign ports, and 15,416 tons went coastwise; of the manufactured iron despatched 3,810 tons went to foreign ports and 3,862 tons went coastwise; and of the steel shipped 29,685 tons went to foreign ports and 10,049 tons went coastwise. Scotland was by far the heaviest buyer of pig-iron, taking 13,119 tons; Germany being second with 2,364 tons; whilst Italy accepted 2,245 tons; France, 2,187 tons; Belgium, 1,616 tons; Wales, 1,570 tons; America, 1,550 tons; and Norway, 1,157 tons. The Cape of Good Hope, with an import of 1,276 tons, was the largest receiver of manufactured iron. Among the principal importers of steel were:—West Africa, 5,279 tons; India, 5,024 tons; Australia, 4,010 tons; and Argentine Republic, 3,669 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Shipping Company's Difficulty.—Sir Gilbert Garnsay, of Messrs. Price, Waterhouse and Co., has been appointed receiver and manager on behalf of the debenture holders of Gould Steamships and Industrials, Limited, the well-known Cardiff ship-owning, shipbuilding and marine engine makers. Floated on the crest of the post-war shipping boom in 1920, with a capital of 3,000,000*l.*, it acquired the tonnage of the Griffiths Lewis Steam Navigation Company, Limited, and the Dulcia Shipping Company, Limited, and subsequently took over Messrs. Richardson, Duck and Co., Limited, shipbuilders, Stockton-on-Tees, and the marine engineering works of Messrs. Blair and Co., Limited, Stockton-on-Tees. Mr. Walter Gould has been retained by the receiver to manage the eight steamers of the company, viz., the Grelbank, Grelcaldy, Greldon, Greleden, Grelhead, Grelisle, Grelstone and Grelwen, totalling over 60,000 tons deadweight. The directors of the company are Mr. James Childs Gould (chairman and governing director), Mr. W. T. Gould (who, with the late Captain J. F. Lewis, was joint managing director), Mr. A. J. Soloman, Mr. A. H. Scott, Sir W. H. Diamond, K.B.E., Lord Ampthill and Mr. W. Annear (who is also secretary). The issued capital of the company amounted to 1,608,104*l.* and there were first 8 per cent. mortgage debentures to the amount of 300,000*l.*, and loans secured by debentures and interest thereon totalling 120,292*l.* The steamships, investments at cost less depreciation, were shown in the assets at 2,932,170*l.*

The Coal Trade.—In the quarter ended December 31 last, 11,176,800 tons of coal were raised in South Wales, of which 10,484,570 tons were disposed of at 20*s.* 6·34*d.* per ton. This was 6·28*d.* below the net cost of production, which amounted to 21*s.* 0·62*d.* per ton. In the previous quarter there was a loss of 8·8*d.* per ton, the cost of production being 4·14*d.* per ton more and the selling price 1·62*d.* per ton more than in the last quarter of the past year. The wages cost per ton was reduced from 14*s.* 11·14*d.* to 14*s.* 7·57*d.*, and the total cost of production from 21*s.* 6·68*d.* to 21*s.* 2·94*d.* The number of workpeople employed was lowered from 219,285 to 209,010, and the earnings per manshift worked from 10*s.* 10·63*d.* to 10*s.* 10·30*d.*, while the output per manshift worked was increased from 15·88 cwt. to 16·24 cwt.

The Tinplate Trade.—The Welsh tinplate stabilisation scheme has come to an end, and there is now a free market for tinplates with the current price round 21*s.*, compared with the minimum under the scheme of 22*s.* 1½*d.* The reason for the collapse of the scheme is that selling was being carried on at less than the minimum price.

ASSOCIATION TECHNIQUE MARITIME ET AÉRONAUTIQUE.—The annual meeting of the Association Technique Maritime et Aéronautique will take place on May 25, 26 and 27, at the offices of the association, 7, Rue de Madrid, Paris (8e). A number of important papers are to be considered. A detailed programme will be issued shortly. The annual dinner of the association will be held on Monday evening, May 25, at the Hôtel Lutetia, 43, Boulevard Raspail.

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W.1, announces that the Egyptian Ministry of the Interior invite tenders until June 10, 1925, for the supply and installation of three mechanical sand filters of the gravitation type.—The Bosphorus Ferry Service Company proposes to place orders in the near future for three ferry boats.—The Minister of Ways and Works has laid before the Chilean Government a programme for the construction of 240 bridges at an estimated cost of 900,000*l.*—The Victorian Government Railways Commissioners invite tenders for the supply and delivery of one hydraulic spring buckle press. Sealed offers must be presented on the proper form at Melbourne, Australia, not later than July 1, 1925.—The Post and Telegraph Department, New Zealand, invite tenders until July 7, 1925, for the supply of sub-station protectors. All inquiries regarding these tenders should be addressed to the Department of Overseas Trade.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Little change has taken place in the Scottish steel trade since the last report, but prices are all tending easier. The volume of business booked since prices were decontrolled is not heavy in any section, and buyers seem to be holding back as long as they possibly can. The demand for shipbuilding material is extremely poor, despite the fact that very low prices are being quoted by makers. These latter may be an inducement when new tonnage is being considered, and it is hoped that shipowners may enter the market again soon. The black sheet makers duly followed the other steel makers in the freeing of prices, but the result has not been to stimulate business; on the contrary, it has created a certain amount of unsettlement, and home buyers are less in evidence because of the hope that lower prices will yet prevail as competition gets keener. The export trade is very much as it was and is little affected, the current demand being poor. Galvanised varieties are steady. The following may be taken as the current prices:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 8*l.* 17*s.* 6*d.* per ton; sections, 8*l.* 7*s.* 6*d.* per ton; and sheets ⅜ to ½ in., 10*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—A quiet tone still prevails in the West of Scotland malleable-iron trade, and producers are really doing very little at the moment. Not only are orders scarce, but inquiries are not coming forward for anything good in the way of tonnage. The steel re-rolling branches are also quieter, although they have a fair amount of work booked. Prices are inclined to be weaker, but "Crown" bars are still quoted at 11*l.* 12*s.* 6*d.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—There has been no improvement in the state of the Scottish pig iron trade this week, and a quiet tone is very general. The current demand is of the poorest, and inquiries do not hold out much hope of any revival in demand in the near future. Stocks on hand are large. To-day's prices, which are inclined to get weaker, may be taken as follows:—Hematite, 4*l.* 10*s.* 6*d.* per ton, delivered at the steel works: foundry iron, No. 1, 4*l.* 10*s.* per ton, and No. 3, 4*l.* 7*s.* 6*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 2, only amounted to 601 tons. Of that total 551 tons went overseas and 50 tons coastwise. For the corresponding week of last year the figures were 2,175 tons foreign and 39 tons coastwise, making a total shipment of 2,214 tons.

Scottish Shipbuilding.—Judging the shipbuilding industry in Scotland from the tonnage launched during the month of April, one would be inclined to conclude that the trade was in a very flourishing condition. The reverse is, however, unfortunately the case, because the number of new vessels booked during the month was only seven—six to be built on the Clyde and one on the East Coast—as against 28 launched. The conditions at the yards are gradually getting worse, and already this year some 90 vessels have been put into the water, while new contracts fixed up during the same period only total a very small percentage of that number. The future is being much dreaded by builders, and unless a very speedy improvement takes place and there is a rush of fresh orders in the near future the outlook for the industry will be very grave. The figures for the past month rank as the second highest total for the month of April, and, while not in themselves a record, they contribute largely to make a record output for the first four months of the year. The details are as follows:—

	April.		Four Months.	
	No.	Tons.	No.	Tons.
The Clyde	24	94,046	76	237,504
The Forth	4	471	8	3,775
The Tay	—	—	2	6,300
The Dee and Moray Firth	—	—	4	3,280
Totals	28	94,517	90	250,859

The record Clyde output for the month of April was in 1913, when the total was 119,305 tons, which brought the four months' figures up to 237,161 tons. The latter total has now been passed to the extent of 343 tons, and the average monthly output for this year to date is nearly 60,000 tons, which is an undoubtedly fine figure.

PERSONAL.—The business known as Light Steelwork, Limited, of 178, York-road, London, N.W.1, in voluntary liquidation, has been acquired by Mr. J. Charles Moore, the late Managing Director, and a new company, to be known as Light Steelwork (1925) Limited, and in which Mr. Moore will act in a similar capacity, is in process of formation. The offices will be transferred after May 10 to 25, Station-road, Harlesden, London, N.W.10.

THE FORTHCOMING SHIPPING, ENGINEERING AND MACHINERY EXHIBITION.—At a luncheon held at the Holborn Restaurant on Thursday, April 30, at which representatives of the Ship and Boat Builders' Association were invited to meet the Committee of the forthcoming Shipping, Engineering and Machinery Exhibition and representatives of the Society of Motor Manufacturers and Traders, it was announced that, largely owing to the interest shown by the S.M.M.T., it had been possible to arrange for the exhibition to be held at Olympia from November 23 to December 5. By selecting these dates any clashing with the British Empire Exhibition is avoided.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—To-night at 4.30 p.m., at John-street, Adelphi, W.C.2. Indian Section. "Indian Meteorology," by Sir Gilbert T. Walker, C.S.I., M.A., F.R.S. Wednesday, May 13, at 8 p.m. Joint meeting with the Royal Aeronautical Society and the Anglo-Batavian Society. "The Non-Stop Flight to the Netherlands East Indies" by Mr. Thomassen A. Thuessink Van der Hoop.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 6 p.m., at Storey's-gate, S.W.1. Extra General Meeting. Fourth Report of the Steam Nozzles Research Committee.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—To-night at 6.30 p.m., at the Engineers' Club, Coventry-street, W.1. "Lessons of 1924," by Captain W. H. Sayers.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: SOUTH-EASTERN DISTRICT.—Saturday, May 9, at 11.15 a.m., at the Town Hall, Worthing. Discussion on "Recent Municipal Works in Worthing." Various visits.

THE INSTITUTE OF TRANSPORT: YORKSHIRE SECTION.—Monday, May 11, at 5.30 p.m., at the Town Hall, Leeds. "Some Practical Statistical Units," by Mr. A. E. Kirkus.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, May 12, at 6 p.m., at Great George-street, S.W.1. Annual General Meeting.

THE INSTITUTE OF TRANSPORT: LONDON CONGRESS.—Wednesday, May 13, to Saturday, May 16, at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2, Wednesday, May 13, at 10 a.m. "Ministry of Transport Requirements, 1925," by Colonel Sir John Pringle, C.B. "Airships and their uses both as Commercial Vessels and in Time of War," by Commander C. D. Burney, C.M.G., M.P., R.N. At 2 p.m. Various Visits. At 7 p.m. Dinner at the Hotel Cecil, Strand, W.C. 2. Thursday, May 14, at 10 a.m. "The Co-ordination of Rail and Road Transport," by Mr. D. R. Lamb. At 2 p.m. Various Visits. Friday, May 15, at 10 a.m. "Arterial Roads in Relation to Town Planning," by Mr. A. E. Brookes. "Modern Dock Equipment," by Mr. H. J. Deane, M.Inst.C.E. At 2.20 p.m. Various Visits. Saturday, May 13, at 9.17 a.m. Visit to Southend.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, May 13, at 6.30 p.m., at the Institution of Electrical Engineers, Victoria-embankment, W.C.2. "Lock and Block," by Mr. T. S. Lascelles.

THE OPTICAL SOCIETY.—Thursday, May 14, at 7.30 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W.7. "The Fundamental Law of Annealing," by Mr. F. W. Preston, B.Sc. "The Dimensional Accuracy of Mr. Hampton's on 'The Annealing of Glass,'" by Mr. F. W. Preston, B.Sc. "A Note on the Cosine Law," by Mr. T. Smith, M.A., F.Inst.P. Exhibition of Apparatus and Instruments by Messrs. W. Watson and Sons, Limited.

THE WEST BROMWICH ENGINEERING SOCIETY: RADIO SECTION.—Friday, May 15, at 7.30 p.m., at the Technical School, West Bromwich. Lecture, "Radio Valves," by Mr. R. C. Clinker, M.I.E.E.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 15, at 9 p.m., at Albemarle-street, W.1. "Recent Developments in Magnetism," by Professor C. G. Darwin.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: YORKSHIRE DISTRICT.—Saturday, May 16, at 10 a.m., at the Town Hall, Wath-upon-Dearne. "Municipal Works and Undertakings, Wath-upon-Dearne," by Mr. Harry Cranage. Various visits.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: SOUTH-WESTERN DISTRICT.—Saturday, May 16, at 11 a.m., at the Town Hall, Tiverton. "Nearly 40 Years' Municipal Work in a Small Borough," by Mr. J. Siddalls. Discussion on "Housing Under Recent Legislation." Various visits.

THE LÖFFLER SYSTEM OF HIGH-PRESSURE STEAM GENERATION: ERRATUM.—Professor Löffler asks us to make a correction in the article under the above title which appeared on page 473 and 474 of our issue of April 17. In referring to the vaporiser of his novel system we said, in the last two lines of the article on page 474, "the drum is pressed out of special steel and provided with screwed-in covers." It is one of Professor Loffler's particular points that the drum, though of special construction and seamless drawn, is made out of ordinary mild (Siemens-Martin) steel.

CONTRACTS.—The Underfeed Stoker Company, Limited, of Aldwych House, London, W.C.2, has secured orders, among others, for the supply of eight travelling grates for use at the Plymouth Electricity Works, five Underfeed stokers for the Koninklyke Steam Packet Company, an air heater for use at Chatham Dockyard, and a soda grate to be supplied to Messrs. Pirie and Co., of Aberdeen.—The Sperry Gyroscope Company, Limited, of 15, Victoria-street, London, S.W.1, have supplied a gyro-compass, gyro-pilot and helm angle indicator for the Commonwealth and Dominion liner Port Melbourne.—Messrs. Shell-Mex, Limited, of Kingsway, London, W.C.2, have secured a contract for the supply of spirit for the new air mail service operating between Cape Town and Durban.

THE REGULATION OF THE MURRAY RIVER; HUME RESERVOIR.

(*For Description, see Page* 565)

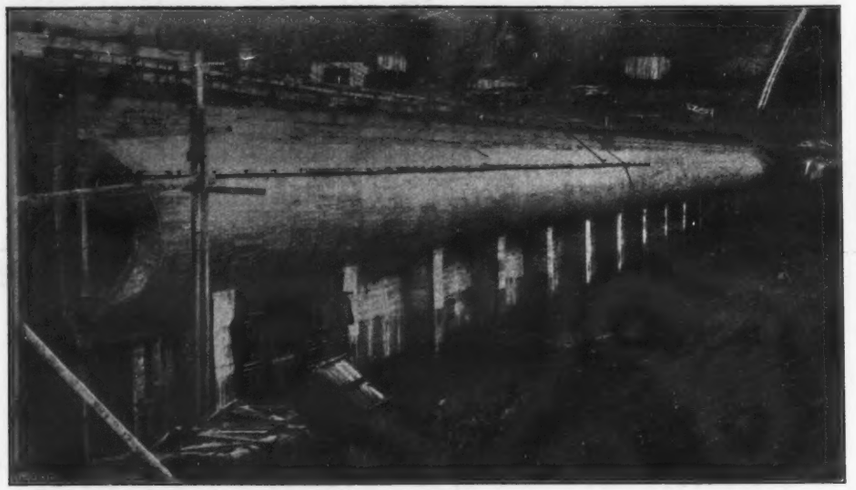

FIG. 106. CORE WALL AND INSPECTION TUNNEL OF EMBANKMENT SECTION.

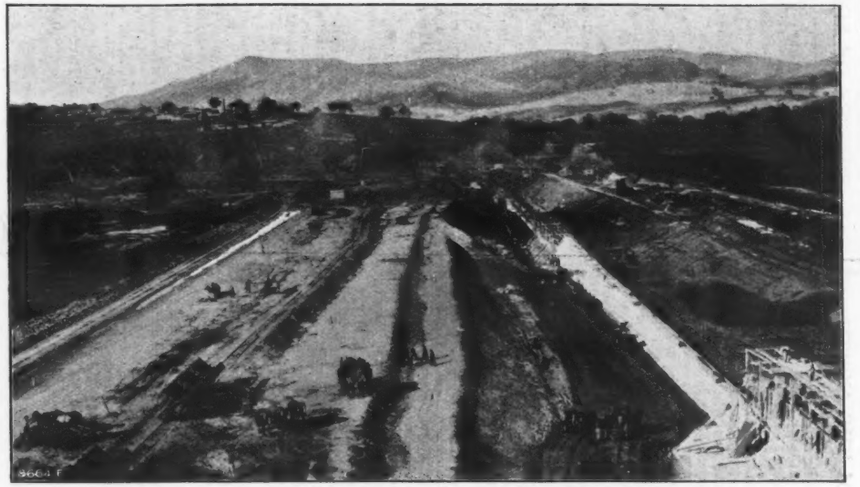

FIG. 107. EXCAVATION AND FILL ON EMBANKMENT SECTION.

FIG. 108. GENERAL VIEW OF TOWNSHIP ESTABLISHED IN CONNECTION WITH THE VICTORIA SECTION OF THE WORK.

THE WORKS OF SIR WILLIAM ARROL AND CO. (SWANSEA), LIMITED.

(*For Description, see Page* 561.)

FIG. 4. THE GIRDER SHOP.

FIG. 5. ONE OF THE MAIN BAYS.

(*To face page* 562.)

THE WORKS OF SIR WILLIAM ARROL AND CO. (SWANSEA), LIMITED.

(*For Description, see Page* 561.)

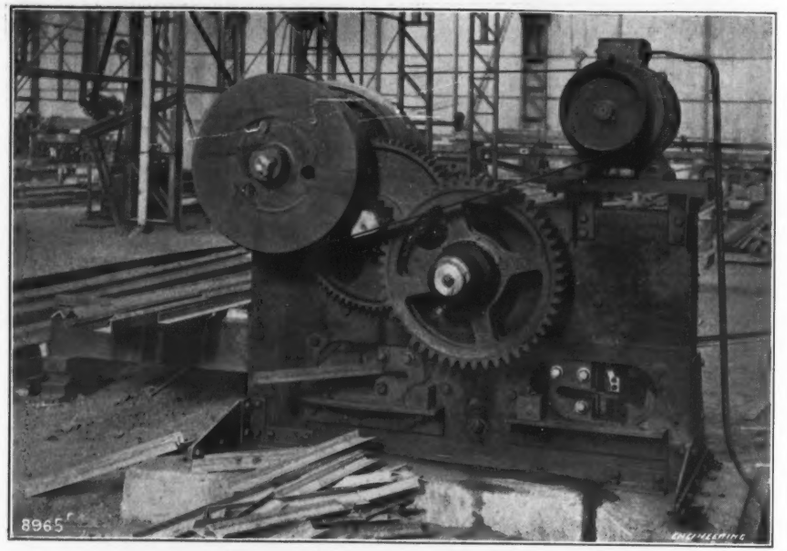

FIG. 6. ANGLE BAR AND TEE CROPPING MACHINE.

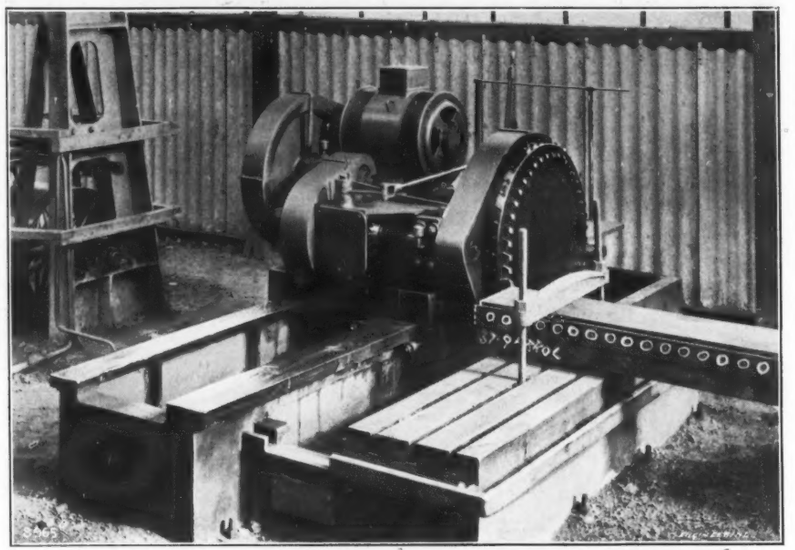

FIG. 7. END-MILLING MACHINE.

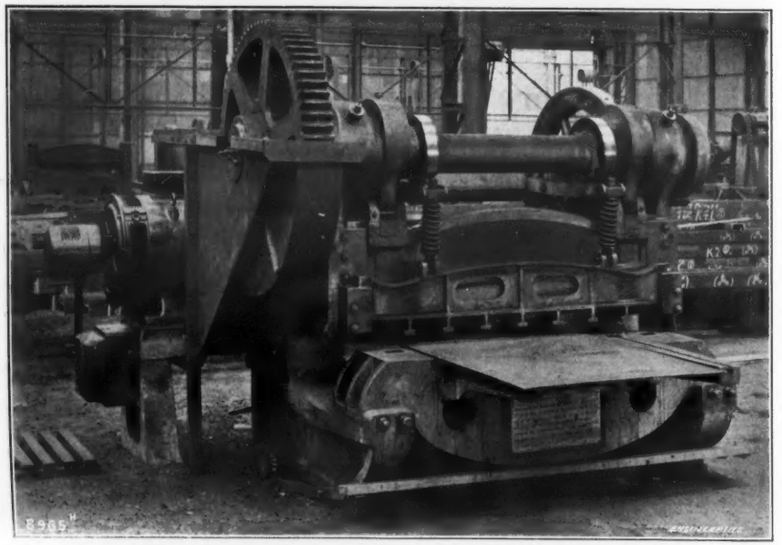

FIG. 8. GUILLOTINE SHEARING MACHINE

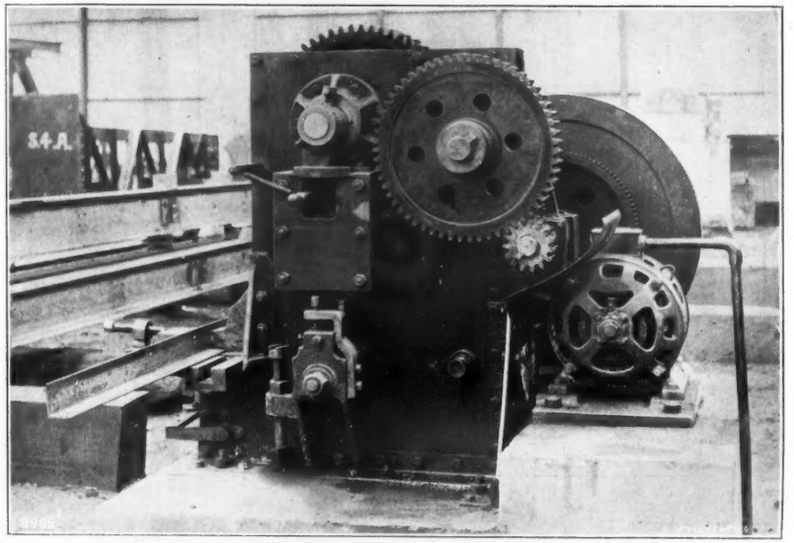

FIG. 9. ANGLE AND JOIST NOTCHING MACHINE.

(*To face page* 563.)

STRAIN DETECTION IN MILD STEEL BY SPECIAL ETCHING.

(*For Description, see Page* 585.)

FIG. 1. YIELD POINT.

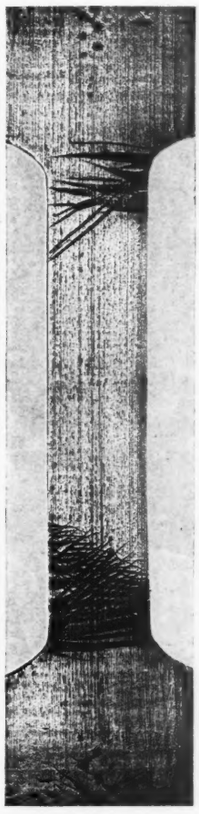

FIG. 2. 0·5 PER CENT. ELONGATION.

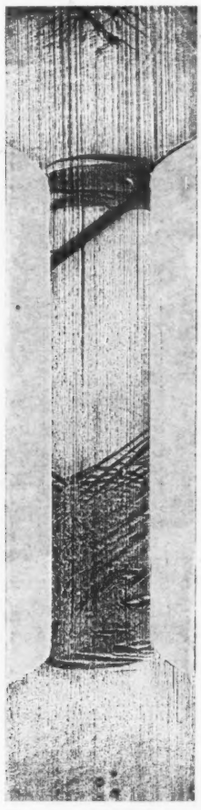

FIG. 3. 1 PER CENT. ELONGATION.

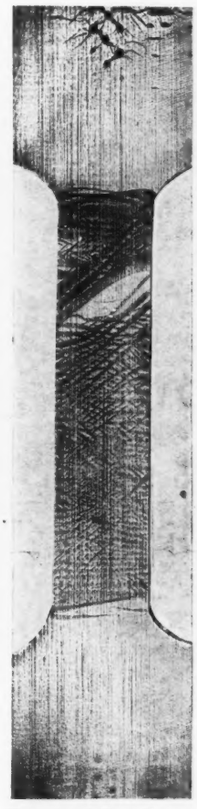

FIG. 4. 2 PER CENT. ELONGATION.

FIG. 5. 4 PER CENT. ELONGATION.

FIG. 6. 6 PER CENT. ELONGATION.

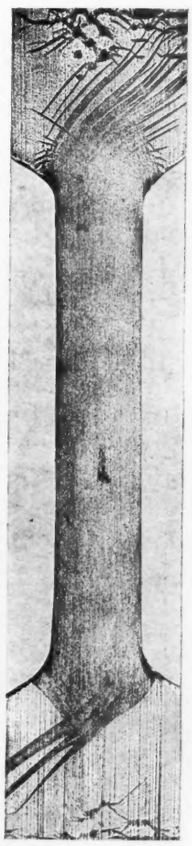

FIG. 7. 10 PER CENT. ELONGATION.

FIG. 8. 15 PER CENT. ELONGATION.

FIG. 9. 20 PER CENT. ELONGATION.

FIG. 10. BROKEN AT 20 PER CENT. ELONGATION.

FLAT TENSILE TEST BARS OF CONVENTIONAL SHAPE, 8-IN. LONG, STRAINED, SECTIONED AND ETCHED.

(*To face page* 586.)

STRAIN DETECTION IN MILD STEEL BY SPECIAL ETCHING.

(*For Description, see Page* 585.)

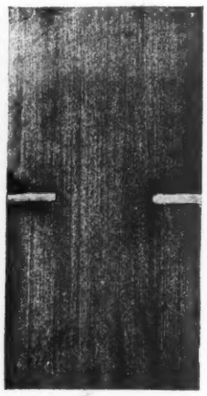

FIG. 13.

FIG. 14.

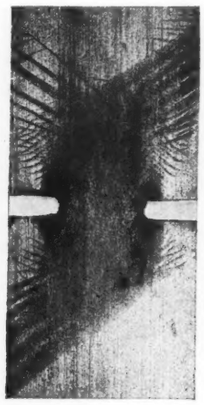

FIG. 15.

FIGS. 13 TO 16. FLAT NOTCHED BARS, STRAINED IN TENSION TO THE YIELD POINT, 2½, 5 AND 10 PER CENT. (FRACTURE) ELONGATION RESPECTIVELY (ON 2-IN.), SECTIONED AND ETCHED. (TWO-THIRDS ACTUAL SIZE.)

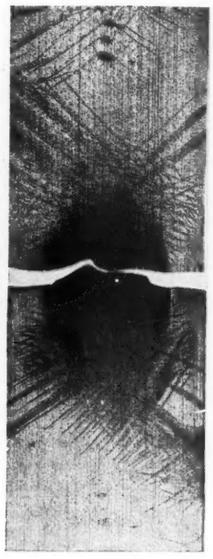

FIG. 16.

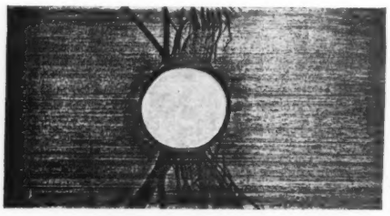

FIG. 17.

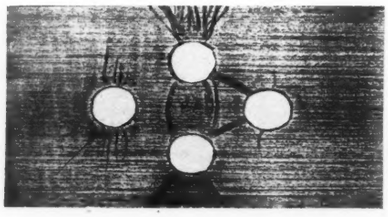

FIG. 19.

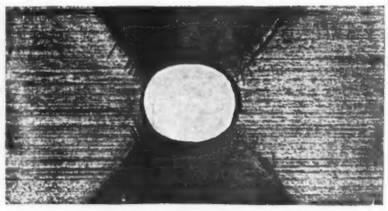

FIG. 18.

FLAT BARS, WITH ONE CENTRAL HOLE, STRAINED IN TENSION TO THE YIELD POINT AND 2½ PER CENT. ELONGATION (ON 4-IN.) RESPECTIVELY, SECTIONED AND ETCHED. (TWO-THIRDS ACTUAL SIZE.)

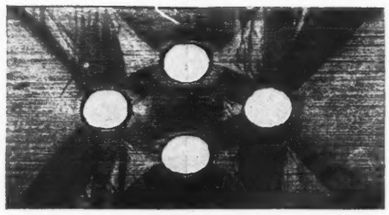

FIG. 20.

FLAT BARS, WITH FOUR HOLES, STRAINED IN TENSION TO THE YIELD POINT AND 2½ PER CENT. ELONGATION (ON 4-IN.) RESPECTIVELY, SECTIONED AND ETCHED. (TWO-THIRDS ACTUAL SIZE.)

FIG. 21.

FLAT BAR REPRESENTING SCREW THREAD, STRAINED IN TENSION TO YIELD POINT, SECTIONED AND ETCHED. (TWO-THIRDS ACTUAL SIZE.)

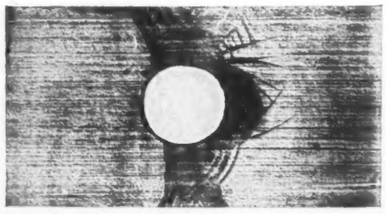

FIG. 22.

FLAT BAR WITH PEG IN CENTRAL HOLE, STRAINED BY LOADING PEG AND ONE END OF BAR. SECTIONED AND ETCHED. (TWO-THIRDS ACTUAL SIZE.)

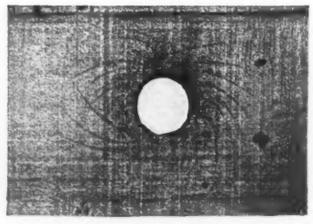

FIG. 23.

½-IN. DIA. HOLE IN PLATE ENLARGED TO $\frac{11}{32}$-IN. BY DRIFTING. PLATE SECTIONED AND ETCHED. (TWO-THIRDS ACTUAL SIZE.)

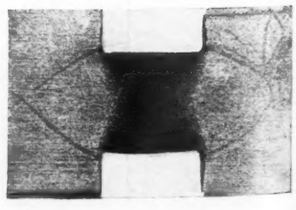

FIG. 24.

CYLINDER COMPRESSED 2 PER CENT. SECTIONED AND ETCHED. (TWO-THIRDS ACTUAL SIZE.)

(*To face page* 587.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand. London, W.C.2.

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ENGINEERING.

FRIDAY, MAY 8, 1925.

THE FINENESS OF PORTLAND CEMENT.

IN order to ensure the strength, soundness and durability of work carried out with Portland cement it has been found necessary to lay down certain conditions and tests with which the cement must comply before it is used. The object of these is to show that the cement has been properly manufactured from suitable materials, finely and intimately mixed, thoroughly burned, and ground sufficiently fine to be cementitious, *i.e.*, capable of setting and hardening. The requirements have been formulated into specifications, which are generally very similar, although they are varied to a certain extent to suit the practice of different engineers and surveyors. Probably the most commonly used specification is that of the British Engineering Standards Association, although this is considered by some to lag considerably behind the present quality of cement. Of the different tests, one of the most important and necessary is that relating to the fineness of grinding. Up till the present this quality has been tested by shaking a given sample of cement through a sieve having a certain number of holes per square inch and weighing the part which remains on the sieve to ascertain the proportion that has passed through. This has been commonly taken as showing how much of the cement is cementitious, or active, and how much is inert matter, usually called residue. Actually it does not indicate this, and it is only a rough and ready test at the best. It has been accepted, however, as generally good enough, although a very large proportion of the cement which does go through the sieve is certainly as inert, from a setting and hardening point of view, as the residue, both being of no more use in the work than sand or small clinker would be. The sieve test is also all the more unreliable owing to the fact that the wire or silk of which the sieve is formed may be of varying thickness, which cannot easily be checked by the ordinary tester.

With the recent introduction of much finer cement the sieve test is becoming still more unsatisfactory. Even when using the finest obtainable sieves the residue left is so small that it is difficult to determine the exact proportion it constitutes of the whole, although it by no means follows that the cement passed is all cementitious. For example, one of the finest cements on the market, which is stated to leave only 0·8 per cent. on a 180 by 180 sieve, when tested for flour or cementitious matter was found to contain only 72·3 per cent., with about 28 per cent. of inert matter. Another make which gave 2 per cent. of residue on the 180 by 180 sieve, contained 67·5 per cent. of flour and 32·5 per cent. of residue.

With regard to the nature of the cementitious matter or flour, the only apparent explanation is that in burning the carbonate of lime, silica, alumina, &c., the grains are fused together and become hard lumps, or granules, of clinker. In grinding, these are reduced, and if reduced sufficiently, the grains are separated, becoming soft at a certain stage and being capable of combining with, or being acted upon by, the water used in gauging; they are therefore capable of setting and hardening. On the other hand, cement not reduced to this point, will not set or harden, and is of no more value in the work than sand would be. This latter fact has been denied or questioned, but if any sample of residue has been found to set or harden, the effect must have been caused by cement flour adhering to the grains, or by flour being knocked or worn off by the action of the trowel used in gauging. The latter reason would be much more probable if the cement were gauged by the old Faija machine. It also accounts for the fact that the more cement is knocked about in gauging, the better, to a limited extent, is the result of the test.

However, in order to prove the comparative uselessness of residue for setting and hardening, and also to show whether or not it is affected by water, the following test was once made. Some cement was taken containing the usual 40 per cent. of flour and having a tensile breaking stress of between 400 lb. and 450 lb. per square inch at seven days. The flour of this sample was separated by a Flourometer (see ENGINEERING, vol. lxxi, page 809), and the residue left was placed in water and soaked for a month. It was then taken out, dried, and ground by pestle and mortar until it contained the same proportion of flour as the original cement. In a subsequent tensile test it withstood the same stress as the original cement, showing that no part of it had been killed or affected by the water, and thus rendered incapable of setting or hardening. The larger the proportion of flour in cement the greater will be its tensile strength and the quicker it will harden. The two special cements above mentioned show that this is correct as, when mixed with three parts of sand to one of cement, the breaking stresses, even at 24 hours were 340 lb. and 400 lb. per square inch, respectively. In order to test whether the strength of cement varies with the proportion of flour, cement capable of giving the usual tensile test result of about 400 lb. per square inch at seven days has been taken, and the residue, after removing the flour originally present, ground down by pestle and mortar until it was all flour. This flour was found to withstand a tensile test of 1,000 lb. per square inch at seven days, or approximately what it might be expected to stand according to the proportion of flour in the original cement.

The fact that the residue is inert and uninfluenced by water may, however, only be taken as correct when the cement has been properly manufactured and is perfectly sound. If this is not the case it is likely, sooner or later, to blow or disintegrate. Residue will certainly blow, the length of time before this happens probably depending, to a greater

or lesser extent, upon the size of the grain. It should be said that with the present system of mixing, washing and thorough burning, together with the scientific checking at each and every stage of manufacture that is now usual, the chances of getting an unsound cement have been very greatly reduced. Unsound cement may, however, result from carelessness or accident, and, if so, the greater the proportion of residue the greater the danger. The flour of an unsound cement is by no means so dangerous as the residue, seeing that whatever alteration occurs in the flour affects it at once while setting or hardening, and not, as in the case of the residue, after the work has been completed.

When the method of separating the flour was first invented some years ago, it was found, generally speaking, that the cement in ordinary use contained about 40 per cent. of flour, and this percentage was generally adopted as a minimum for specifications. Some of the surveyors and engineers who approved of the flour test and realised the value of the flour, asked for, and succeeded in obtaining, a larger proportion of flour in the cement they were buying, the manufacturers supplying it when it was insisted upon. To-day it is possible to get cement with a much increased proportion of flour. The old proportion of 40 per cent. was obtained by the manufacturer without much difficulty, as cement was then burned in shaft or chamber kilns, and therefore contained a proportion of ash, underburnt material, &c., which was easily reduced to flour. With the introduction of the rotary kiln, conditions were changed, particularly at the commencement, when, while experience in working was being obtained, the clinker was generally burned too hard, and contained no soft underburnt material. In a particular case, one of the largest firms manufacturing cement accepted a large contract for which cement containing a certain proportion of flour was specified. It was taken for granted that grinding to a certain sieve fineness would satisfy the test for flour. This, however, was not the case, and the cement on being tested in the Flourometer, proved to contain only 20 per cent.

As regards the question of the value of more flour, it may be said that cement containing, say, 70 per cent. of flour is worth, as regards the proportion of sand it will stand to give the same strength, about 75 per cent. more than cement with only 40 per cent. of flour, provided, of course, the sand used is suitable for taking the place of the residue that has been removed. Cement with this increased value, however, is being put on the market at the present time at only about 20 per cent. increase in cost. In the United States, as well as on the Continent and in this country, the matter has aroused great interest, particularly at the present moment, when much finer cements are being adopted.

In conclusion, it may be questioned whether the sieve test should not now give way to the more general adoption of the flour test. Although at one time the latter met with great opposition from manufacturers, being regarded as unnecessary and introducing difficulties, there is less likelihood of objection to it now. It would also appear that, in connection with such work as is involved in the repairs to St. Paul's Cathedral, the flour question would be a vital one. If cracks are to be filled up and solidified by using cement grouting, it would seem absolutely necessary for the cement to be as fine as possible for it to fill the small cracks and also, if possible, for every grain of the cement to be cementitious. Flour, if procurable, would undoubtedly be the best, especially as there would then be no fear of the flour separating from residue while the grout was being run in; moreover, the hardening would be quicker and better.

ELECTRIC ROAD VEHICLES.

WHILE the potentialities of the electric battery vehicle are generally recognised in this country, the limited extent to which it has been utilised suggests that it is still viewed with considerable suspicion by some transport authorities. On the other hand, its merits have received full recognition in the United States, where over 35,000 such vehicles are in use, and it is interesting to speculate whether the difference in the attitude of the two countries is due to our greater conservatism or to some more fundamental reason.

In a paper read before the Institute of Transport on May 4, Mr. F. Ayton, in discussing this type of vehicle, mentions that an impression persists in some quarters that the batteries employed are unreliable and their life uncertain. Evidence to the contrary is so readily available, however, that we hardly think that this can be a serious deterrent to anyone who contemplates the adoption of the battery vehicle. It would appear that there must be some more cogent reason, and in this connection the examples of users in this country given by Mr. Ayton is suggestive. It is noticeable that these are all carriers, with their headquarters in large towns and having a large local business, and the inference appears obvious that the limiting charging facilities which are available throughout the provinces automatically confines the purely battery vehicle to a few large centres.

Mr. Ayton advocates the extended establishment of public electric vehicle charging stations with garage accommodation as a means of furthering the use of battery vehicles. This proposal is by no means new, and some progress was made in the direction of carrying it into effect prior to the war. In some cases the result of the enterprise then shown has not been such as to tempt power station engineers to extend the experiment. While it is true that every power station which offers facilities for battery charging becomes a new focus from which the operation of battery vehicles becomes possible; the conditions in the district where the facilities are offered may be quite unfavourable to any such development. The battery vehicle is high in first cost, it has a total range of from 30 to 50 miles, it is essentially a slow speed vehicle, and it is not understood by the ordinary garage mechanic. These objections quite outweigh its superior economy in comparison with other types for the small user, and render its legitimate field one in which a frequent stop service combined with full employment can be ensured. These conditions exist in the case of distributing concerns in the larger towns, and for certain municipal purposes such as dust collection; but there may be insufficient business of the requisite type in existence in the case of a small town, unless one concern can secure the control of all the distributing interests, which is unlikely. It is probable that there are still many towns throughout the country where the battery vehicle is practically unknown, but where the conditions are favourable to its operation. In such cases it is hardly to be expected that the station engineer will provide the facilities until he is assured of a reasonable return on the outlay involved, and it would appear that in cases where the municipal authorities control the power supply, they might reasonably ensure such a return by introducing the requisite vehicles.

It is usually taken for granted that the purely battery type of vehicle is entirely unsuitable for long-distance services, and at first sight its limited range, combined with its comparatively slow speed, would appear to make this obvious. As far as the speed is concerned, Mr. Ayton mentions that the speeds attainable on the level vary from 15 to 18 miles per hour for a 30-cwt. van to some 6 or 7 miles per hour for a 5-ton lorry. It will thus be seen that the speed is very appreciably lower than that of a petrol lorry, and that it is not worth while considering whether the difficulty associated with the limited range can be overcome unless this disability is offset by some marked advantage. This would only occur in the event of a considerable resulting economy in running costs, and in this connection it is interesting to note that in his book on *Mechanical Road Transport* Mr. Conradi estimates this reduction as in the neighbourhood of 30 per cent. The only way in which the limited range could be overcome would be by establishing a series of stations where an exhausted battery could be left for recharging and a fully charged battery picked up in its place. Such a scheme would involve the creation of something in the nature of a network of charging stations in conjunction with standardised batteries, but it is not impossible that a development along these lines may take place in the event of a future shortage of imported fuels.

The second part of Mr. Ayton's paper is devoted to trolley 'bus services. This is another development which has only found limited favour in this country, the author stating that it is confined to 14 different undertakings. These are all owned by local authorities with one exception, so that very little evidence is available with regard to this form of transport under private ownership. There can be no doubt, however, that the trolley is cheaper than the petrol 'bus when the traffic requirements are sufficient to justify a regular and frequent service. In widely-scattered districts, where the requirements can be met by a relatively infrequent service, the cost of the permanent road equipment for a trolley 'bus becomes prohibitive, and in such cases the petrol vehicle has an overwhelming advantage. The petrol 'bus also enjoys other advantages, in that a service which has proved to be unprofitable may be abandoned, and the vehicles transferred to another route, without loss; and in that its introduction does not involve the erection of an unsightly superstructure along the roads. The problem for the transport authority who has to decide between the trolley and the petrol 'bus is thus a question of balancing the two latter factors against the probable number of passengers on any contemplated route in a given period. We believe that the limited extent to which the trolley 'bus has found favour in this country merely indicates that in rural districts the balance is generally in favour of the petrol 'bus. In the case of town areas, it is more probable that the conditions will favour the trolley vehicle, but in this case the advocates of the latter are generally faced by the fact that a tramway system is already in existence. There can be little doubt that the trolley 'bus is better suited than the tram to modern traffic conditions as existing in most large towns, but it is hardly to be expected that the authorities concerned should adopt the heroic measure of scrapping the existing tramway rolling stock and permanent way in order to introduce the more convenient, and also probably more economic, system. It is very possible that this may form the ultimate solution of the difficulty in which many tramway undertakings find themselves, but the time is hardly ripe for such a procedure, which would inevitably involve a heavy increase in the rates over a considerable period. The policy of imposing artificial restrictions on petrol 'bus services in places where they enter into direct competition with the tramways may sometimes be defended as a temporary measure, but in the long run the interests of the public can only be served by allowing free competition. In cases where such competition occurs at the present time, the public show a marked preference for the 'bus, and as a result the latter gives the more favourable return. The degree of preference shown is a little difficult to understand, as there is generally very little difference between the time taken by the two types of vehicle to traverse a given distance and the tram is much smoother in its motion. It would almost appear that the public actually prefer the livelier motion of the 'bus. It is impossible at the present time to forecast the outcome of free competition between petrol and trolley 'buses, but it seems reasonable to suppose that if the latter are introduced only in cases where they can be justified by a sufficient traffic density, their superior economy would result in their ultimate preference by the public.

THE PROTECTION OF UNDERGROUND SUPPLIES OF WATER.

BECAUSE of the growth of the population and its increased concentration in cities and towns and also owing to the increased consumption of water by the people, it has become necessary to protect underground supplies against interference through the action of new users reducing what is available for others, and also to ensure that the water obtained is not polluted. The necessity for legislation to ensure the maintenance of the rights of the users may be judged from a few cases. St. Winifred's Well at Holywell, Flintshire, which formerly gave a supply of 4,000,000 gallons of excellent water a day, was drained completely dry in 1917, as the result of lead-mining operations. In another case

heavy pumping at a colliery, three-quarters of a mile further inland than a certain water company's well, caused the drawing in of water from the sea. The supply obtained by the water company was, as a result, greatly contaminated with salt and rendered completely unsuitable for public supply. A special Act of Parliament had to be passed in 1909 to protect the brewers of Burton-on-Trent from any interference with their water supplies by the sinking for water by the local water supply company. A Sub-Committee of the Ministry of Health was established in 1923 to investigate what legislation was necessary to deal with the questions involved. This sub-committee had the assistance of an Advisory Committee of which the nine members were chairmen, engineers or managers of water supply undertakings.

The Sub-Committee has now presented a "Report on Measures for the Protection of Underground Water." This has recently been published by His Majesty's Stationery Office at a price of 2*d*. In it the proposal has been made that some form of State control should be instituted to prevent the harmful results of the present system of allowing anyone to draw supplies without restriction. Under the proposed scheme a licence must be obtained from the Ministry of Health before any work, which might interfere with the supplies of underground water, can be undertaken. In districts where mining operations are conducted, the Ministry of Health will have the collaboration of the Ministry of Mines prior to the holding of a public local inquiry. The Sub-Committee were impressed with the necessity for conferring powers upon all water undertakings through the Ministry of Health for the protection of their supplies from contamination. Wherever any company or person desires to tap the underground water, it is proposed that the concern in question must furnish the Minister of Health with information regarding the quality and quantity necessary in order that the total requirements of the area may be studied.

MOTOR FUELS.

In his third and concluding Howard Lecture, delivered on May 4 at the Royal Society of Arts, Professor Brame reviewed some of the problems upon which research is now concentrated. Tables and curves he exhibited showed that there is little variation in the calorific values of the different kinds of fuel, petrol, benzol, alcohol, on the basis of weight. Purchase is, however, made on the volume basis, and the number of British thermal units produced by the combustion of 1 gallon is higher for the denser than for the lighter fuels. But the possible thermal units are not realised in a motor because combustion is not complete. Theoretically the fuel/air mixture should be so proportioned that, in the case of petrol, the exhaust contains about 14 per cent. of carbon dioxide. The usual mixtures are over-rich; from experiments conducted by the Bureau of Mines American motors seem to work with an exhaust containing only from 7 per cent. to 12 per cent. of CO_2. The advantages claimed are easier starting, better acceleration and greater power. But the combustion of over-rich mixtures must lead to the formation of carbon monoxide and thus to low thermal efficiency. The late Professor W. Watson, who dealt with these problems in his Cantor lectures of 1910, found that the presence of 4·5 per cent. of carbon monoxide in the exhaust meant an efficiency loss of 20 per cent. In the recent American experiments good results were obtained with from 13·7 per cent. to 14·7 per cent. of CO_2, and the highest thermal efficiency was realised with an air/fuel ratio of 17 : 1. Professor Brame's chief objection to weak mixtures was on account of their slow and uneven burning, especially when cold, but recommended for high thermal efficiency, *i.e.*, good mileage per gallon, warm weak mixtures, and for maximum power cool strong mixtures. Power had to be sacrificed to gain economy.

As regards the danger from carbon monoxide poisoning, the experiments made in connection with the Brooklyn tunnel scheme and elsewhere proved that the dangers are very real, even in garages. The absorption of the CO by the blood is slow and varies individually, but 0·2 per cent. is dangerous because even the weak gas quickly makes a man helpless. In a closed garage of 1,500 cub. ft. capacity, Yant found that an automobile created in 8 or 10 minutes an atmosphere containing 0·5 per cent. to 0·7 per cent. of CO, and Professor Brame mentioned that CO accidents have occurred in garages over here.

With respect to fuel composition and efficiency and compression ratio, he referred chiefly to Ricardo's experiments with his variable compression engine, which we illustrated in our issues of September 3 and 10, 1920. By raising the compression ratio from 4 : 1 to 7 : 1, Ricardo increased the indicated thermal efficiency by 36 per cent. But high compression introduces the risk of pre-ignition, and there was further detonation or pinking which, when present, would give rise to true pre-ignition. Detonation, Professor Brame suggested, probably arose in the following way: The high compression raised the temperature of the mixture nearly to the ignition point; when the spark passed, part of the mixture burned with progressive rapidity, setting up a pressure wave immediately in the flame front, and this wave carried the compression further, so that the remainder burned almost instantaneously. The detonating wave occurred when a certain critical pressure was set up at which the combustion advanced at the rate of the velocity of sound. Similar phenomena were observed with high explosives which first burned quickly. There was apparently no direct connection between ignition temperature and tendency to detonate; thus carbon disulphide had a low ignition point (275 deg. C. in air) and stood a compression ratio of 5·15 : 1, whilst a petrol of ignition point 353 deg. detonated at a 4·85 : 1 compression. The explanation might be in the rate at which the initial combustion reaction speeded up to the detonation point, acting somewhat in the way that mercury fulminate did when used as detonator for high explosives. That action was not due to the power of the fulminate, nor to its own rate of detonation which was comparatively low, but to the rapid increase in the velocity of the explosion from the moment of ignition to the development of the true detonation wave. Physical conditions largely influenced the tendency to detonate: the distance the flame had to travel depended upon the size and shape of the combustion space and the position of the sparking plug; good turbulence diminished the tendency, and the turbulence was itself influenced by the piston speed and the position of the inlet ports; weak and over-rich mixtures were less liable to detonate because of their lower rate of combustion.

Professor Brame reproduced Ricardo's table of the highest useful compression ratio, A, applicable without detonation, the corresponding thermal efficiency B, and C the minimum fuel consumption at A in pints per brake horse-power.

	A	B	C
Petrols ...	4·55 to 6·0 : 1	30·2 to 34·9	0·402 to 0·484
Benzene (98%)	6·9 : 1	37·2	0·355
Alcohol (98%)	7·5 : 1*	40·4	0·533
Methylated spirit ...	6·5 : 1*	38·5	0·609

* Detonation not actually reached.

In general the tendency to detonate decreases in this order: paraffins, naphthenes (cyclo-paraffins), aromatic hydrocarbons, alcohol; in mixture, the liability to detonate was proportional to the percentages of the various hydrocarbons. But there was some discrepancy with the naphthenes, possibly due to the analytical difficulties of naphthene determination. That benzenes were not inclined to detonate was known to motorists, and Ricardo had emphasised the advantages of motor spirits containing fair proportions of benzene and its homologues. Of the latter Ricardo found toluene most efficient to prevent detonation; giving toluene the value 100, which had been adopted by the British Engineering Standards Association. Ricardo found that xylene had the value 85 and benzene 67. But Midgley and Boyd, in their investigation of "anti-knocks," placed xylene above toluene, Ricardo's own results were not concordant, as S. W. Sparrow had pointed out, and the adoption of the toluene standard seemed open to question.

The single-cylinder engine which Midgley and Boyd used for their investigation of the prevention of detonation had four detachable heads for varying the compression ratios and a special piston on which the "bouncing pin" rested. This long rod was normally held down by an adjustable spring. When detonation jerked it up, the pin pressed together two contacts fixed above it and started electrolysis in a voltameter, which served for the measurements. We have on other occasions, referred to these researches* on substances preventing or promoting detonation, and to the statistics collected on the risks due to the use especially of the organic lead compounds, which have been found to be extraordinarily effective in preventing detonation. The whole subject, Professor Brame remarked, was still obscure. Why traces of isopropylnitrite promoted detonation, and 1 part in 215,000 of lead tetraethyl suppressed it, was unknown. According to Ormandy and Craven the anti-knocks did not raise the ignition point, nor did the knock-inducers lower it. The risks involved deserved serious attention. In 1924, some 200 million gallons of "ethyl gasoline" had been distributed in the United States. When the lead ethyl was used alone, the lead was deposited over the sparking plugs. That trouble had been overcome by adding some volatile organic halogen compound (mostly ethylene bromide) to the tetraethyl, so that lead bromide was formed and blown out with the exhaust. The "ethyl fluid" mixture was distributed in small sealed cylinders; but there was great danger in its manufacture, and its production was stopped in some works last winter where fatalities had occurred. There was the further danger of the poison gases discharged into the air with the exhaust. A committee of investigation appointed by the Bureau of Mines found that none of the animals exposed to the exhaust gases died of lead poisoning—there were some, possibly natural deaths—and that the few men experimented with did not suffer distinctly, probably because 75 per cent. of the gases were exhaled again, and of the 25 per cent. not exhaled much was eliminated in secretions. None of the usual cumulative effects of lead poisoning were observed.

One cannot help feeling that it was premature to express any opinion upon cumulative effects, after experiments lasting a few months, and the latest cables (May 5) from New York indeed, report that the Ethyl Gasoline Corporation (a subsidiary of the General Motors Corporation and of the Standard Oil Company) have suspended all sales of ethyl fluid until a United States conference has met on May 20. The State of New York prohibited the manufacture of the ethyl fluid when five people had become insane and had died in the laboratories of one of the Companies mentioned. Since none of the "dopes" so far tried, moreover, have given an increase in power, there is no great inducement to encourage these dangerous experiments—apart from the study of the nature of the effect, the exploration of which need not endanger the public and factory workers.

GRANULATION OF SLAG.—Reviewing recent processes for the granulation of blast furnace and other slags and the drying of the products, members of the blast-furnace committee of the Association of German Iron Masters express a preference for dry over wet methods of granulation and recommend the Buderus air-drying process (Stahl und Eisen, April 9). In this latter process, due to Dr. Jantzen, the slag passes from the blast furnace through a water-cooled conduit into a shute which enters the upper end of an inclined rotating tubular drum. Underneath the end of the shute is the mouth of the nozzle through which compressed air mixed with water is forced in. The air blast sprays the slag and hurls the grains against the wall of the drum. Water in adjustable proportions is mixed with the air and more water is admitted into the drum: atmospheric air is drawn through the drum. A grain of any desired degree of moisture is obtained, from 0 per cent. to 10 per cent. and more, and the process is applicable also to highly-acid slags which foam and will not sink in wet-granulation processes. Chemical, miscroscopic and polariscopic examinations show that there is no essential difference between air-granulated and water-granulated slags and that they can be ground with about the same ease. The advantages of the air-granulation are that it yields a much more compact slag requiring less than half the space in storing and transport, and that no subsequent drying is needed.

* ENGINEERING, vol. cxviii, page 616 (October 31, 1924).

THE LATE MR. D. B. MORISON.

IT is with great regret that we have to announce that Mr. D. B. Morison, for so many years managing director and chairman of Messrs. Richardsons, Westgarth and Co., Limited, died at Nice, on April 23, at the age of 66.

Donald Barns Morison was a Devonshire man by birth, and was educated at the Ashburton Grammar School. On leaving this, he proceeded to the Clyde, and entered the works of Messrs. John Elder and Co., as an apprentice. During his apprenticeship he attended the technical classes of the Andersonian College, which is now known as the Royal Technical College.

As is well known, Messrs. John Elder and Co. played a leading part in the introduction of the triple-expansion marine engine. Mr. A. C. Kirk, after experimenting with the Propontis, in 1874, and with the yacht Isa, in 1878, had made a definite success with the SS. Aberdeen, in 1882. Mr. Morison was then in the drawing office of the works, and gained invaluable experience during this period of transition, which was extended under Mr. Bryce Douglas, who was Mr. A. C. Kirk's successor. Deeming it advisable to obtain sea experience, Mr. Morison next entered the service of the Orient Steam Navigation Company, from whose ship, the Austral, he had a narrow escape when she sank at Sydney. Leaving the sea, Mr. Morison was next employed in the drawing office of Messrs. T. Richardson and Sons, Limited, of Hartlepool. Here the impression he made was such that he was rapidly promoted to the post of assistant manager, and he subsequently, at the early age of 28, succeeded Mr. Wyllie as general manager to the company. It has often been observed that an exceptionally good man can hardly be promoted too early to a position of responsibility. Mr. Morison completely justified the confidence of his directors, and when the company was reconstructed in its present form, he became joint managing director, then sole managing director, and ultimately the chairman of the company.

Under his direction, the Hartlepool engine works were modernised and improved. He was, moreover, a strong believer in the value of experiment. Many engineering firms often appear to be afraid of a new idea, and seem to prefer to confine themselves to manufacturing pure and simple. They may buy novelties offered as ostensibly fully worked out, but will undertake no pioneering even in minor matters, on their own account. Mr. Morison had no sympathy with this too popular policy, and was quite prepared to "practicalise" a promising idea himself, rather than purchase it "ready-made" from some other firm. He was thus responsible for the design of many novel engine accessories, and when, moreover, a demand for heat accumulators arose, he was again prepared with his own designs. He pursued the same policy in the matter of jet air pumps for condensers. To the improvement of the condenser he devoted very special attention. Messrs. Charles Parsons and Co. were, no doubt, the pioneers in this matter, and Mr. Morison did not begin his own experiments till 1904. As was perhaps natural, his earlier designs were more suitable for reciprocating engines than for steam turbines, but these were modified progressively as experience accumulated, and finally resulted in the present simple patterns which have proved highly successful in power-station service. Mention may also be made of his suspension furnace, which has been largely adopted in marine boilers.

It is probable that his life was shortened by the heavy responsibilities which fell to his lot during the war. In the year 1918, for example, his firm engined no less than 51 ships, the total output representing nearly a quarter of a million horse-power.

He also took an active part in the movement for standardising mercantile marine engines in order to cope more effectually with the piratical plans of the German Admiralty. He read a valuable paper on this subject before the North-East Coast Institution of Engineers and Shipbuilders in 1917. In addition to his other war services he raised a volunteer section of the Royal Engineers of which he was the commanding officer.

Possibly, the work in which he took the greatest pride was the ultimate success of the campaign for raising the status of the naval engineer. In this movement he played a very prominent part. In a paper read before the North-East Coast Institution of Engineers and Shipbuilders in 1900, he drew attention to the great growth in the engineering establishment of the Navy and to the lack of any corresponding improvement in the conditions of service.

In 1878 the personnel belonging to the executive branch was 27,911, whilst the engineering personnel numbered 5,627. Twenty years later the relative figures were 44,331 and 22,289. This large increase in the engineering establishment had been accompanied by no corresponding increase in the number of qualified engineers. Mr. Morison showed that, in comparison with our mail services, the engineering branch of the Navy was greatly undermanned, although the duties imposed on the engineers were year by year being increased.

THE LATE MR. D. B. MORISON.

They had, in fact, been made responsible not merely for the power plant, but for practically all the mechanisms, inclusive of gun mountings, turret gear torpedo tubes and air compressing machinery. In spite of this there had been no improvement in the status or pay of the engineer. No engineer was permitted to report directly, either to the Admiralty or to the Engineer-in-chief. All communications had to be made through the captain who could comment on or suppress his engineer's reports.

Great dissatisfaction naturally arose, and at the time of Mr. Morison's first paper on the subject, there was a growing difficulty in securing an adequate supply of recruits. This led to action on the part of the Admiralty, which if taken by a private firm would have been regarded as a serious breach of contract.

Mr. Morison's demand for an improvement in the engineers' status greatly annoyed some of the old school admirals, one of whom declared that any Lascar was quite capable of running engines. However, the pressure was continued. An important step towards meeting the legitimate demands of the engineers was the formation of the Osborne Cadet School, in which no distinction was made between aspirants to the different branches of the service. The final triumph came in 1915 when executive status was granted to all engineer officers.

This decision was very gratifying to Mr. Morison, who expressed his satisfaction in a paper read in the same year before the North-East Coast Institution.

Mr. Morison also took a leading part in devising that society's scheme of research. He early recognised the duty of employers to promote the technical education of apprentices, and some 20 years ago arranged at the Hartlepool works an Apprentice Advancement Scheme, and later on founded a scholarship of 150*l.* per annum to enable the recipient to take a year's course at the Armstrong College, Newcastle.

Amongst the last of his public services was the part he played in promoting the tests of marine oil engines, now being carried out under the auspices of the Institution of Mechanical Engineers, &c. He may be said to have originated this research, offering special facilities for trials on a ship engined by his firm, and his example was then followed by others.

He took an active part in many scientific and technical societies, being a Fellow of the North-East Coast Institution of Engineers and Shipbuilders; a member of the Council of the Institution of Naval Architects; a member of the Council of the Institution of Mechanical Engineers; a member of the Consultative Committee appointed by the institutions in connection with the Board of Trade, and a member of Lloyd's Technical Committee appointed by the Institution of Naval Architects. He was a liveryman of the Worshipful Company of Shipwrights, and a freeman of the City of London.

THE IRON AND STEEL INSTITUTE.

THE fifty-sixth annual general meeting of the Iron and Steel Institute was opened yesterday and is being continued to-day in the hall of the Institution of Civil Engineers. In the earlier proceedings the chair was taken by the retiring president, Sir William Ellis.

The usual formal business having been transacted, the Secretary read the annual report of Council. This stated that the number of members on the roll on December 31, 1924, was 2,093. The report then made reference to the honours conferred on several members, to the income and expenditure of the Institute during the past six years, and to last year's meetings, these including the Mining and Metallurgical Congress, of which the Institute in its corporate capacity was one of the promoters. It also entered into the various activities of the Institute, and concluded by mentioning the different bodies on which several members had acted as representatives, and by recording changes in the membership of Council.

In presenting the statement of accounts, Mr. Illtyd Williams, the hon. treasurer, pointed out that the income for the year 1924 amounted to 8,068*l.*, exclusive both of the Carnegie Scholarship Fund and of the interest on investments constituting the Special Purposes Fund; on the other hand, the expenditure amounted to 7,568*l.*

Sir William Ellis then inducted into the chair the newly-elected president, Sir Frederick Mills, Bart., who presented the Bessemer Medal to Professor Thomas Turner, of Birmingham University.

In doing so, Sir Frederick stated that his first duty as president was to make the award of the Bessemer Gold Medal, and it was with great pleasure that he offered it, in the name of the Institute, to Professor Turner, in recognition of his distinguished services in the advancement of the science of the metallurgy of iron and steel. For many years his name had been familiar to members of the Institute as Professor of Metallurgy at Birmingham University, and as the head of a department which had become famous for its metallurgical researches and its publications dealing with many branches of ferrous and non-ferrous metallurgy. Sir Frederick called to mind Professor Turner's early researches on the influence of silicon on the properties of cast-iron, the results of which met with immediate and wide application. His studies of the effect of each of the elements present in cast-iron had been said to have laid the foundation of scientific iron founding.

Professor Turner's investigations included studies on the formation and varieties of graphite in cast-iron, on the microstructure of castings, on the

changes in volume during solidification, on the influence of the rate of cooling and of casting temperatures, not to mention the nature and properties of metals other than iron and steel, on which a vast amount of work had been expended, including the invention and design of a sclerometer for the purpose of testing their hardness. Professor Turner, Sir Frederick added, had been president of the Staffordshire Iron and Steel Institute, and was at the present time president of the Institute of Metals. He was also a member of Council of the Iron and Steel Institute. He was, further, honorary member of a number of metallurgical societies in the Dominions and in foreign countries. His own University lately manifested its appreciation of his work by establishing a trust for the award of Thomas Turner Gold and Bronze Medals, and prizes for metallurgy at the University.

Professor Turner, in acknowledging the award of the Bessemer Medal, thanked the President, Council and members of the Institute for the honour they had conferred upon him by selecting him as the recipient of the honour on the present occasion.

Sir Frederick Mills then delivered his presidential address, in which he reviewed certain aspects of the economics of the heavy iron and steel industry. He referred to the paper by Sir William Larke and Mr. Birkett, read last year before the Empire Mining and Metallurgical Congress, and dealing with the problems that beset British iron and steel manufacture.* He also alluded to the presidential address to the Institute by Mr. Carnegie, covering the economics of the iron and steel industry so far as they concerned several American works.† The iron and steel industry of this country, Sir Frederick stated, when working at full capacity, gave direct employment to 300,000 persons, and indirectly in engineering and shipbuilding to 1,000,000. The question which presented itself for solution at the present time was as to whether we were entitled as a nation to continue in it, or had we to let it go.

The colossal development in steel manufacture in the United States dated from the adoption by that country of Bessemer's invention; the United States outstripped us in point of tonnage, as also did Germany, following the introduction of Bismarck's Tariff Laws in 1878. Sir Frederick feared that we in this country could not say that we had progressed steadily or prosperously. Our pig-iron output last year was 30 per cent. below that of 1913, and whilst our output of steel was approximately the same, no less than 2,500,000 tons of iron and steel were imported, which would have helped to make a good showing had it been produced here. Our total steel output would then have been about 11,000,000 tons, giving us second place among the nations; 100,000 more men would have been employed instead of being in receipt of the dole, and, in addition, the price of the home product would not have been regulated by the "give-away" prices of the foreign steel.

We were faced at home with two plain facts. The cost had, since pre-war days, increased some 50 per cent. to 60 per cent. Selling prices had increased by only 30 per cent. to 40 per cent.; the scant margin of pre-war profit had disappeared, and the industry had become unprofitable. Costs in this country in regard to two items—coal and labour—had increased enormously, and were altogether too high. The price of metallurgical coal had advanced some 80 per cent. since pre-war days. In regard to labour cost, Sir Frederick wanted to make it clear that there could be no quarrel with the average earnings of the men employed in the iron and steel trades, although the disparity in earnings of the highest and the lowest seemed to call for adjustment. He wanted simply to emphasise the cost per ton for labour. The percentage of "ultimate" labour in the cost of a ton of steel amounted to at least 92·5 per cent. In the matter of coal the ultimate labour cost was quite 90 per cent. In view of these figures, if we are to improve our costs we must so order our affairs, both public and private, as to obtain a better output for the labour now employed, that is, a lower cost of labour per ton. A ton of steel should not be regarded merely as such, but as "nine-tenths of a ton of labour." If a 5-ton ingot could have been made with half the number of men, or if two such ingots could have been produced by the same number of men, costs of manufacture would have been halved. That could be done; it would result in benefit and increased employment. We could thus make and sell more tons in competition with the world, and thereby employ more men.

Sir Frederick said there was still much room for improvement in our use of coal. He questioned whether we were correct in our policy of rejecting, for the most part, the use of large gas engines using coke-oven and blast-furnace gases, the discovery of B. H. Thwaite, and first employed at Wishaw in 1896. The process was almost universal on the Continent; some Continental works were making as much as 50,000 tons of steel per month, using no other source of power, except in the case of emergency. He also laid stress upon the desirability for the latter to amalgamate their interests and to arrange for the segregation of orders, concentrating these into the areas and works most suitable for their production.

The discussions at the morning and afternoon sessions on Thursday and to-day will be reported in our next issue. Several of the papers taken on Thursday are, however, reproduced on pages 585, 588 and 591 of this issue.

(To be continued.)

* See ENGINEERING, June 13, 1924, page 761.
† See ENGINEERING, May 8, 1903, page 629.

MODEL EXPERIMENTS IN AERODYNAMICS.

ON Wednesday, April 29, at the Rooms of the Aeronautical Society, 7, Albemarle-street, W.1, Dr. D. W. Taylor, Secretary to the U.S. National Advisory Committee for Aeronautics, delivered the annual Wilbur Wright Memorial lecture. The subject considered was "Some aspects of the Comparison of Model and Full-Scale Tests," and, incidentally, the lecturer gave a singularly clear exposition of the laws of dynamic similarity. He pointed out that we had no *a priori* grounds for believing that any scale relationship should exist between a model and its prototype. It was conceivable that the resistance offered by a fluid to the passage of a body through it might depend upon six physical constants, viz., the size of the body, its speed, the density of the fluid, its viscosity, its compressibility and the acceleration of gravity. If each and all of these quantities had a sensible effect on the resistance, then there would be no law of comparison between a model and a full-sized aeroplane or airship. As matters stood, however, the term involving gravity could be ignored, since wholly submerged bodies had no wave-making resistance. Again, the term involving the compressibility of the air could be also neglected, as with neither aeroplanes nor airships was the speed of sound approached. Thus, the scale effect due to the viscosity term alone remained, and the resistance R could accordingly be written in the form

$$R = \rho L^2 V^2 F\left(\frac{L V}{\nu}\right),$$

where ρ denoted the density of the fluid, L some characteristic dimension of the aeroplane or airship, and V the speed, whilst ν represented the kinematic viscosity of the air and $\frac{L V}{\nu}$ was "Reynold's number."

The formula showed, that in order that tests on a model should be directly comparable with full-scale tests, the term $\frac{L V}{\nu}$ should be the same for both. In ordinary wind-tunnel experiments, this would mean that a model on 1/20th scale should have a speed twenty times as great as the full-sized aeroplane. This was quite impracticable, and accordingly the plan had been adopted in the United States of operating the wind tunnel under a pressure or a vacuum, thus varying ν.

A range of ν from, say, 1 to 200 was thus obtainable. Dr. Taylor said, that at the outset some trouble had been experienced in the tests made at pressures of 20 atmospheres, as in

Fig. 1. LIFT AND DRAG CHARACTERISTICS AS TESTED IN THE VARIABLE DENSITY WIND TUNNEL FROM 1 TO 19·92 ATMOSPHERES.

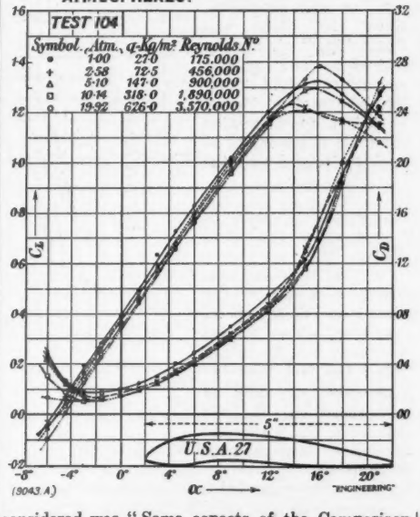


Fig. 2. LIFT AND DRAG CHARACTERISTICS AS TESTED IN THE VARIABLE DENSITY WIND TUNNEL FROM 1 TO 20·0 ATMOSPHERES.

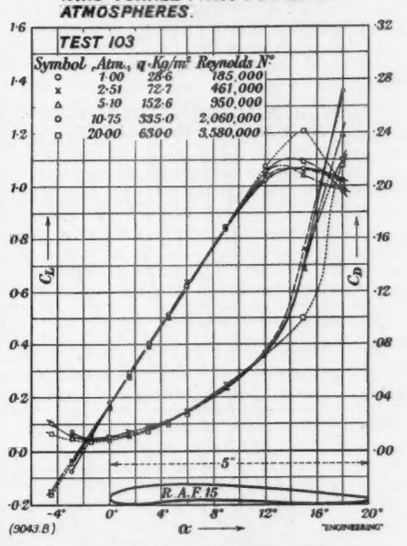
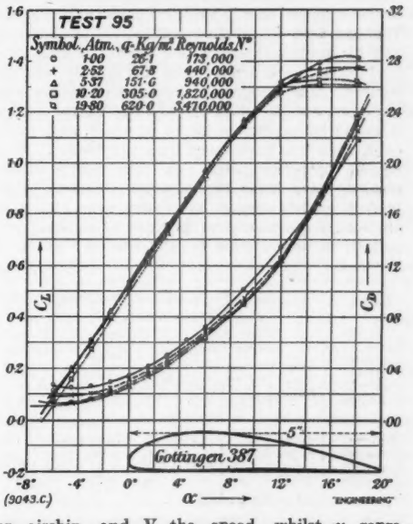


Fig. 3. LIFT AND DRAG CHARACTERISTICS AS TESTED IN THE VARIABLE DENSITY WIND TUNNEL FROM 1 TO 19·8 ATMOSPHERES.



these conditions a tiny electric spark might suffice to start a fire. The tests so far made included a series on three typical aerofoil sections, viz., an American section, an R.A.F. section, and a German (Göttingen) section. Of these, the R.A.F. section was the thinnest, and the German the thickest. The results showed that the scale effect was more important in the case of drag than of lift, and that thin sections showed less scale effect than thicker ones. The curves obtained are reproduced in Figs. 1 to 3. The general results indicated that for aerofoil sections, the scale effect was, after all, a secondary matter, though by no means negligible, if close estimates were aimed at.

In the case of propellers, Dr. Taylor said that the difficulty of making accurate full-scale propeller experiments in full flight made it, for the present, almost essential to rely solely on model experiments. This had been done with success in the marine field, and air propellers being free from the danger of cavitation, were even more favourably circumstanced. The designer of airplane propellers was, therefore, able to adopt efficient blade sections that it would be impossible to use in water, and, moreover, need not have more than two blades. Two-bladed propellers were not satisfactory in sea service, being liable to excessive vibration. Two-bladed models tested in water gave, however, efficiencies quite as good as those of airplane propellers, as was shown by the results entered in Table 1.

TABLE I.—*Maximum Efficiencies of Two-Bladed 16-In. Propellers in Water.*

Camber Ratio at 0·75 Radius.	Mean Width Ratio.	Pitch Ratios. 0·4.	0·6.	0·8.	1·0.	1·2.	1·5.
0·1241	0·075	—	—	—	0·85	—	—
0·0744	0·125	—	—	—	0·84	—	—
0·0465	0·200	0·56	0·71	0·78	0·82	0·83	0·84
0·0338	0·275	—	—	—	0·79	—	—

No propeller, Dr. Taylor pointed out, could have an efficiency of 100 per cent., since its thrust was dependent upon the sternward momentum generated in the fluid passing through it, and at any stated speed of advance the efficiency fell off as the thrust increased. According to the simplified theory of the propeller, the curves of constant efficiency were parabolas when $\frac{T}{V^2} = \left(\frac{\text{Thrust}}{\text{Velocity}^2}\right)$ was plotted as ordinate against the propeller diameter. Tests of actual propellers gave results in qualitative agreement with this, but the efficiency lines, instead of increasing indefinitely as the diameter increased and $\frac{T}{V^2}$ diminished, reached a maximum and then fell off again, as indicated in Fig. 4, which referred to propeller E of Table II. If in level flight a propeller were working above the parabola of maximum efficiency, and an attempt was made to climb, the value of $\frac{T}{V^2}$ would increase and the efficiency necessarily fall off. If, on the other hand, the propeller was operating in the field below the line of maximum efficiency, its efficiency would increase (up to a certain limit) on attempting to climb.

Writing T to denote thrust instead of resistance and ignoring all scale effects but those depending on the viscosity of the air, the thrust could be expressed, Dr. Taylor continued, in the form

$$T = \rho V^2 D^2 F\left(\frac{\nu}{D V}\right).$$

in which we again met the Reynold's number complication. Experiments on aerofoils had, however, shown that the scale effect with them was secondary, and it was still more so with propellers, since the blade was "attacking" air already disturbed, and greater turbulence might therefore be expected. Hence, as a first approximation the scale effect might be entirely ignored and the thrust expressed as

$T = \rho V^2 D^2 \times$ a numerical coefficient depending on pitch ratios and blade proportions.

If this formula were exact, a model of any size, tested at any speed, would tell all we needed to know, but, bearing in mind the fact that the expression was only an approximation, it was advisable to make the models as large as possible and to run them at high speeds.

Dr. Taylor suggested that the characteristics of a propeller might be specified in terms of the ratio between pitch and diameter, the ratio between the average width of the blade and the diameter, and in terms of camber ratio at three-quarters of the propeller radius. He pointed out that the propeller was a kind of middleman, and might be regarded either as driving the airplane or as absorbing power from the motor.

A convenient variable against which to plot propeller efficiencies was $\frac{(\text{R.P.M.})}{\sqrt{P}} \cdot \frac{1}{\sqrt{\rho V^5}}$, where P was the power absorbed, ρ the density of the air, and V the speed.

The term P was sometimes conveniently replaced by V, the useful work done. In addition to the efficiency of the propeller, it was necessary to plot some function involving the propeller diameter, and a convenient function for this purpose was $\frac{D \cdot (\text{R.P.M.})}{V}$, which might be denoted by δ.

Dr. Taylor gave in Table II particulars of model propellers tested for the United States National Advisory Committee.

The results of the tests are plotted in Figs. 5 and 6.

The curves showed that the possible efficiency of an aeroplane propeller was essentially a question not of propeller design, but of the requirements to be met. Given the power to be absorbed or delivered, the speed, and the revolutions per minute, the maximum possible efficiency was fixed, and might well be below the 80 per cent. conventionally regarded as normal. For a given combination of power, speed and revolutions there was a definite pitch ratio giving maximum efficiency, but on each side of this there was a relatively wide range of nearly constant efficiency. Hence keeping the revolutions, power and speed constant, we might use a small propeller with a coarse pitch, or a large propeller with a fine pitch with about the same efficiency. The curves showed also that the variation of efficiency with variation in the blade section was remarkably small. Thin blades

Fig. 4. ACTUAL PROPELLER EFFICIENCY IN AIR DERIVED FROM MODEL PROPELLER TESTS.

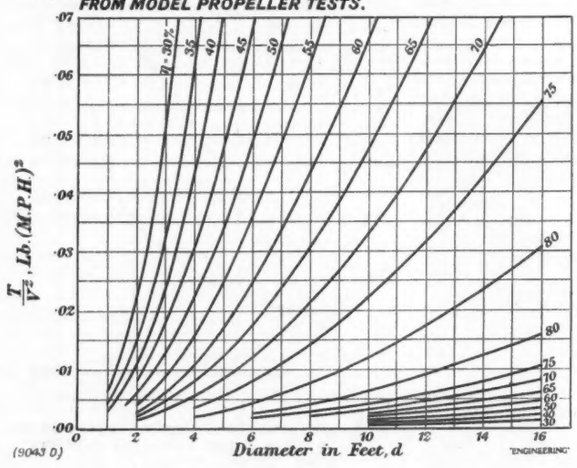


Fig. 5

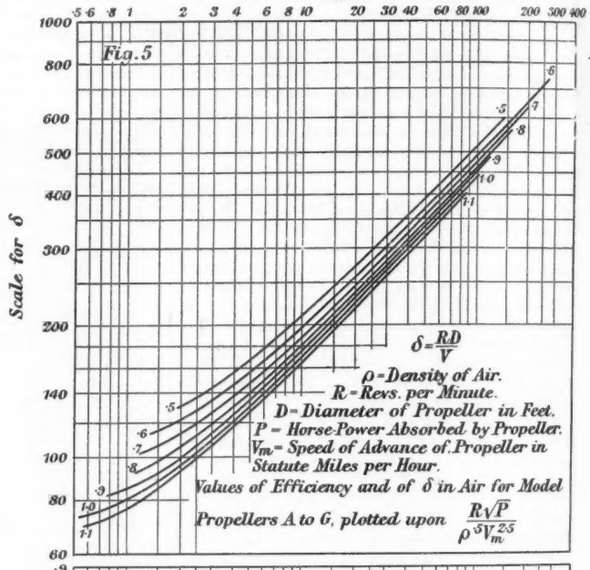

·5 ·6 ·8 1 2 3 4 6 8 10 20 30 40 60 80 100 200 300 400
1000
800
600
500
400
300
200
140
100
80
60
Scale for δ
δ = RD/V
ρ = Density of Air.
R = Revs. per Minute.
D = Diameter of Propeller in Feet.
P = Horse-Power Absorbed by Propeller.
Vm = Speed of Advance of Propeller in Statute Miles per Hour.
Values of Efficiency and of δ in Air for Model Propellers A to G, plotted upon R√P / ρ^·5 Vm^2·5

Fig. 6.

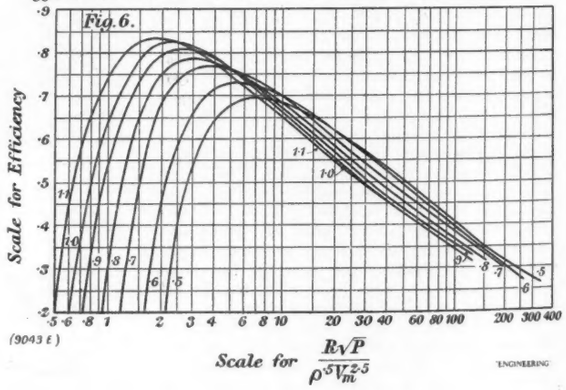


TABLE II.

Designation.	Pitch Ratio.	Maximum Width Ratio.	Mean Width Ratio.	Camber Ratio at 0·75 Radius.
A	0·5	0·0833	0·070	0·107
B	0·6	0·0833	0·070	0·107
C	0·7	0·0833	0·070	0·107
D	0·8	0·0833	0·070	0·107
E	0·9	0·0833	0·070	0·107
F	1·0	0·0833	0·070	0·107
G	1·1	0·0833	0·070	0·118
H	0·7	0·0833	0·070	0·128
I	0·7	0·0833	0·070	0·139
J	0·7	0·0833	0·070	0·107
K	0·7	0·0666	0·086	0·107
L	0·7	0·1000	0·085	0·107
M	0·7	0·0769	0·066	0·107

and narrow blades acted as normal blades of slightly greater diameter. Dr. Taylor pointed out that systematic diagrams like Figs. 5 and 6 derived from one family of propellers, might be used with a good deal of accuracy to forecast the results to be expected from propellers having another type of blade, once one of the new type had been tested.

Whilst full-scale experiments were, as stated, difficult to carry out, some tests of this kind had been made in America. These showed that in all cases the full-scale coefficients were greater than those derived from the model. The average difference was about 8 per cent., though with one type of propeller the discrepancy was very small. Part of this disparity between the model and full-sized tests was due to a true scale effect, and another part to the circumstance that in free flight the propeller shaft made a varying angle with the actual flight path, whilst in the model tests the two were always parallel. Still a third factor, however, appeared to be involved, viz., the deformation of the blades under stress. This deformation was much greater in the full-scale tests than it was in the case of the model experiments.

LABOUR NOTES.

ORGANISED Labour's extremists, as was to be expected, have received the engineering employers' proposals relating to wages and working hours with anything but favour. They are describing it as "the beginning of an organised attack on the shorter week," and calling upon the workers in every industry to unite in opposing it. So far, however, there has been no criticism of the details, and it is on their details that the proposals must stand or fall. There is no foundation for the allegation that the proposals are, in effect, an attack on the shorter week. On the contrary, they are a perfectly straightforward, business-like effort to put the British engineering industry into a position to cope with the competition of foreign industries, working longer hours, paying lower wages, and operating under much more favourable trade-union conditions. The British worker is certainly being invited to work for a greater number of hours per week, but neither on day-shift nor on night-shift is he being asked to work for as long as his fellows in most Continental countries. And he is to be paid for the additional hours worked. His war bonus is also to be increased. On its face, that does not look like an organised attack on the shorter week or an attempt to depress working conditions to the Continental level. Moreover, the men have been given a definite promise by the Engineering and Allied Employers' National Federation that it will reconsider the matter with the unions if other countries bring their hours effectively into closer relation to those in this country. The new proposals are clearly due to economic necessity and not, as is alleged, to a desire to depress working conditions.

The rank and file of engineering operatives—whose leanings are not at all towards extremism—naturally dislike the idea of increasing working hours. Many of them, however, admit that necessity compels the employers to do something, and none is showing the contemptuous disregard of the details of the proposals that the extremists are showing. In several areas workers are going into the figures, and by reckoning the added hours as overtime at current rates are convincing themselves that there would be a reduction instead of an increase under the proposals. The answer to that seems to be that everybody's earning power would be increased under the proposals, whereas only a few are at present intermittently working overtime. Briefly expressed, the position is that on the proposed basis of 50 hours per week the earnings of the skilled time-worker would be increased 8·8 per cent., and those of the time-working labourer 9·8 per cent. Men on payment by results would, of course, earn more. In comparisons of night-shift rates, which some of the workers are making, the new proposals are necessarily seen to less advantage. But the fact ought not to be overlooked that with easier night-shift rates and conditions more night shifts would be worked and a greater number of men find employment. When the London night-shift rate was time and a-half no night shifts were worked, it will be recalled, in the area, whereas elsewhere in the country where the rates were easier, night shifts were common. But the earning capacity of men on night shift would be increased under the new proposals, and when the matter is fairly reckoned that becomes plain.

The Ministry of Labour states that, on April 27, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,187,000, namely, 910,400 men, 36,200 boys, 208,200 women, and 32,200 girls. On April 20, 1925, the number was 1,202,671, or 922,682 men, 36,252 boys, 211,588 women, and 32,149 girls; while on April 28, 1924, it was 1,047,780, made up of 777,197 men, 35,551 boys, 200,886 women, and 34,146 girls.

According to an official statement issued by the Mines Department, the output of coal in Great Britain during the last quarter of 1924 was 62,428,185 tons. Allowing for 3,881,184 tons for mine consumption and 1,584,686 tons for miners' coal, there were 56,962,315 tons left for disposal commercially. The net costs of production were 18*s.* 4·29*d.* per ton, of which 13*s.* 0·93*d.* went in wages. The proceeds of commercial disposals amounted to 54,089,440*l.*, or 18*s.* 11·90*d.* per ton, a profit of 1,805,542*l.*, or 7·61*d.* per ton. The number of workpeople employed was 1,079,107, the number of manshifts worked 70,363,899, and the number of manshifts lost, 5,801,458. The average output per manshift worked was 17·74 cwts., and the average earnings per manshift worked was 10*s.* 7·04*d.*

In the course of a comment on these figures, the Mining Association says:—"The tonnage of saleable coal raised at 62,428,185 tons is over five million tons less than in the December quarter of 1923. The output per person per shift at 17·74 cwts., while showing the usual seasonal increase over that for the September quarter, is a fraction below that for December, 1923, and, of course, still far below the level which Mr. Justice Sankey declared in 1919 to be a national danger. Average earnings were 10*s.* 7*d.* per shift, and the wages cost 13*s.* 1*d.* per ton, as compared with 10*s.* 10½*d.* and 13*s.* 8*d.* in September, 1924, and 10*s.* 3½*d.* and 12*s.* 7¾*d.* in December, 1923. Owners' credits were 7½*d.* per ton against 1*s.* 4*d.* in September, 1924, and 1*s.* 11½*d.* in December, 1923. The collieries in the exporting districts producing over 50 per cent. of the output of the country, worked at a loss in the aggregate during the quarter. The average pithead price—which includes the price of all slack and small coal and of coal sold for export, and is no indication of the pithead price of domestic coal—was 19*s.*, as compared with 19*s.* 1¾*d.* in September, 1924, and 19*s.* 10¾*d.* in December, 1923."

"It is interesting to note," the statement proceeds, "that in the Eastern federated area, comprising Yorkshire and the Midlands, where the output per person per shift is over 1 ton as compared with 17·74 cwts. for the country as a whole, the wages cost per ton is 9*d.* less, and the average earnings per shift 9*d.* more, than for the whole country. A comparison of the percentage of manshifts lost which could have been worked to the total possible number of manshifts in the various districts is interesting. For the country as a whole, the percentage of lost manshifts is 7·6. Evidence before the Coal Mining Organisation Committee gave 3 to 5 as the figure of unavoidable absenteeism due to sickness, &c. For the Eastern federated area it is 9·3, for Scotland 3·4, for South Wales 7·3, for North Wales 6·8, for Northumberland 8·1, and for Durham 7·8."

At a meeting held recently in the Rhondda District a resolution was passed pledging the miners in the area to strike if by May 2 all the non-union miners had not joined the Miners' Federation. When, however, the appointed time for the stoppage arrived, the great majority of the men declined to cease work. At none of the collieries, it is said, were more than 40 per cent. prepared to obey the strike order, while in several the miners practically decided in a body to take no part in extreme action. The matter has been referred back to the lodges, and the probability is that "moral suasion" will now be used to induce the non-unionists to come in. It would be wrong to infer from this that organised workers in South Wales or elsewhere prefer "moral suasion" to force in matters of this kind. The Rhondda decision to disobey the strike order was due to a belief that the moment was inopportune. When trade revives, a great deal of trouble may be expected in most industries on the question of the employment of non-union men, although the only effective cure for this is, obviously to make the unions themselves so attractive that there will be no need to press any worker to join.

Mr. John Hill, the General Secretary of the Boilermakers' and Iron and Steel Shipbuilders' Society, in the 90th annual report of the society, states that during 1924 the union lost 5,835 members. This loss of membership does not necessarily indicate, he says, a weakening of the organisation. Throughout the year employment was uncertain, and for a large percentage of members there was no employment at all. As a result, many of the members emigrated or left the trade altogether. Some 500 went on superannuation, and 847 died. The net financial result is a drop of 88,913*l.* 17*s.* 6*d.* for the year, the total assets of the society at the end of December last being 152,670*l.* 9*s.* 7*d.* The recent lock-out is stated to have cost the society over 155,000*l.* in dispute benefit alone.

In the annual report of the United Patternmakers' Association, Mr. Allan A. H. Findlay, the general secretary, states that although the membership of this organisation decreased by 171 in 1924, the percentage of unemployed members was halved and the balance of funds increased. The gross income was 90,452*l.* 16*s.* 10*d.* and the gross expenditure 74,543*l.* 14*s.* 6½*d.*, while the net (trade-union) income was 54,811*l.* 0*s.* 5*d.*, and the net (trade-union) expenditure 38,319*l.* 2*s.* 7½*d.* The balance of funds increased by 16,486*l.* 17*s.* 9½*d.*, and now stands at 49,976*l.* 10*s.* 10*d.*—exclusive of the Political Fund—or 4*l.* 4*s.* 8½*d.* per member as at December 31, 1924. The total membership at the end of the year was 11,797.

At a meeting of the Committee of the Miners' International at Brussels, on April 28, Mr. Frank Hodges (Great Britain) was appointed permanent general secretary. The appointment carries with it a salary of 500*l.* per annum, with travelling and other expenses. The holder of the office is debarred from entering Parliament. The committee decided to send a delegation to Soviet Russia to inquire into the conditions in the mines of that country. On its report will depend whether the Russian miners are, or are not, admitted into the Miners' International.

The National Joint Emergency Commission for the Building Industry, which investigated the difficulties that have arisen in London and other centres over summer-time working hours decided that the action of the branches of London operatives in refusing to work the 46½-hour week was a breach of the National Agreement of August 22, 1924. It had no alternative, the Commission went on to say, but to call upon all parties concerned honourably to fulfil the obligation entered into under the terms of the agreement, and it impressed upon all parties, both employers and operatives, the urgent importance of fulfilling national agreements, so that the advantages gained by collective bargaining should not be jeopardised. The finding of the Commission was not received at all well by the London men, but there are hopes that they will eventually fall into line.

The first meeting of the joint committee of shipbuilding employers and shipyard trade unionists appointed to investigate the position of the British shipbuilding industry, with special reference to foreign competition and the steps to be taken to meet it, was held in London on May 1. At the close the following joint official statement was issued:—"A preliminary meeting of the joint committee representing the Shipbuilding Employers' Federation and the shipyard trade unions took place to-day, when there was a full discussion as to the scope of the proposed inquiry and the method of procedure. It was mutually agreed that the proceedings would necessarily be of a confidential character, and that not until any conclusions or recommendations had been arrived at could any public statement be made in connection with the work of the committee. At the same time, both sides recognise the importance of the investigation and the need for the problems with which the industry is faced being investigated as speedily as possible."

Speaking at Cymmer on Saturday, Mr. Ramsay MacDonald put his finger on the weak spot in the argument for joint Russo-British action in the interests of trade-union unity. Moscow's idea is, as is well known, to put the Red International in the place of the Amsterdam International, and out-and-out admirers in this country of Soviet Russia appear to be blind to the dangers of this. Mr. MacDonald sees them clearly enough. "I warn you," he said, on Saturday, "that you must see to it that in getting into friendly relations with Russian trade unions you do not cut yourselves off from French and German trade unionists. Any combination must be one that takes the Amsterdam trade-union movement with it. Any steps cutting us off from Amsterdam are steps towards international disunity." The British sections of most of the trade internationals are well aware of that, as their fellows in Continental countries have repeatedly told them in conferences of the aggressions of the "Reds," but a goodly number of others in high places here are either not so well informed or regardless

of the consequences, and it is to them, no doubt, that Mr. MacDonald's warning was addressed.

The Seventh General Conference of the International Labour Organisation created by the Treaty of Versailles is to meet at Geneva on May 19, when the following subjects will be discussed: (1) Workmen's compensation for accidents; (2) Equality of treatment for national and foreign workers as regards workmen's compensation for accidents; (3) Weekly suspension of work for 24 hours in glass manufacturing processes where tank furnaces are used; (4) Night work in bakeries. The Government have appointed Mr. H. B. Betterton, Parliamentary Secretary to the Ministry of Labour, and Mr. R. R. Bannatyne, Assistant Secretary, Home Office, as Government delegates, and, in agreement with the National Confederation of Employers' Organisation and the General Council of the Trades Union Congress, have nominated Mr. James Lithgow (ex-president of the Shipbuilding Employers' Federation and of the National Confederation of Employers' Organisations) and Mr. E. L. Poulton (secretary of the National Union of Boot and Shoe Operatives, and member of the General Council of the Trades Union Congress), as employers' and workpeople's delegates respectively. Each delegate will be accompanied by advisers. Mr. A. E. Kingham, of the Ministry of Labour, Montagu House, Whitehall, S.W. 1, is secretary to the delegation.

The Late Mr. C. K. Etheridge.—We regret to record the death, which took place on April 28, of Mr. Copeland K. Etheridge, Joint Managing Director of Messrs. Etheridge, Dewar and Co., Limited, marine surveyors, of Seething House, 10, Byward-street, London, E.C.3.

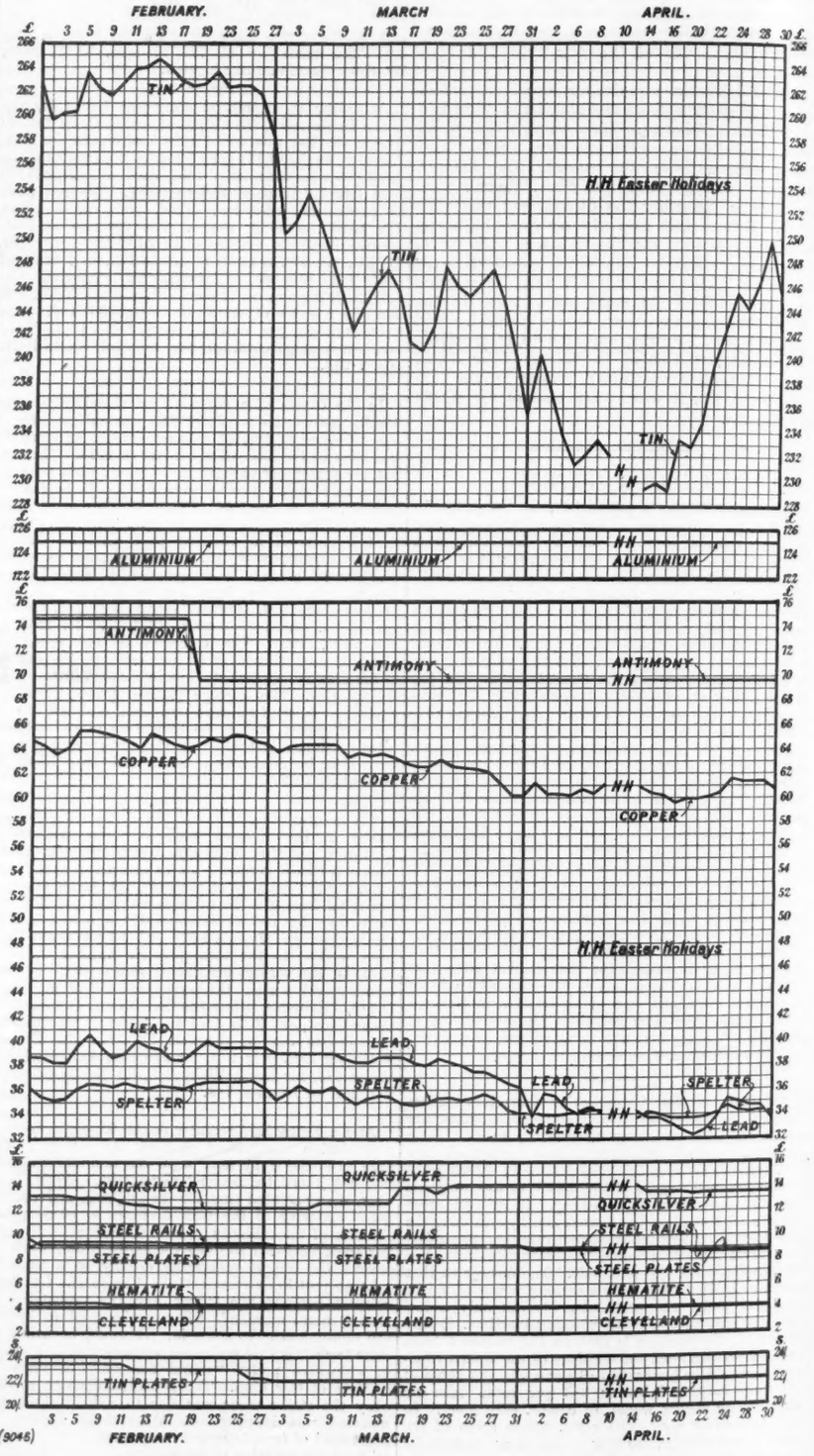
Twist-Drill Making: Erratum.—We regret that in our issue of the 24th ult., page 527, we referred to a catalogue of twist-drill making plant as having been received by us from Messrs. Henry Hunt and Sons. The firm's name should actually have been given as Messrs. Herbert Hunt and Sons, Old Trafford, Manchester, to whose products we have frequently referred in our columns.

Royal Institution.—The annual meeting of the members of the Royal Institution was held on the afternoon of May 1, Sir James Crichton Browne, treasurer and vice-president, being in the chair. The annual report of the Committee of Visitors for the year 1924, testifying to the continued prosperity and efficient management of the Institution, was read, together with the report of the Davy-Faraday Research Laboratory Committee. New members elected in 1924 numbered 78, and 63 lectures and 19 evening discourses were delivered, while the books and pamphlets presented amounted to about 273 volumes, making, with 678 volumes (including bound periodicals) purchased by the managers, a total of 951 volumes added to the library in the year.

The Casale Ammonia Process.—During last year's discussions on nitrogen fixation at the World Power Conference, Dr. J. F. Crowley and Mr. E. M. Bergstrom referred to the Casale process. Dr. Casale, Professor of Chemistry at the University of Turin, in 1916, had been placed at the head of an Italian Government commission charged with the study of synthetic ammonia production and the utilisation of water power for this purpose. The research was supported by Mr. René Lepestre, an American financier, who had large interests in Rome. By 1920, synthetic ammonia was made in Dr. Casale's laboratory; in July, 1923, a plant for the production of 3 tons daily was put in operation, and a plant for 7½ tons has since been erected. Visiting the Casale works at Terni (near Rome) in 1923, the late Dr. J. A. Harker, Dr. Crowley's partner, reported that the process differed greatly from existing processes in detail and was simpler and less costly to instal. On April 30, Messrs. J. F. Crowley and Partners gave a dinner at the Royal Automobile Club to meet Dr. Casale and the Conseil d'Administration of the Casale Ammonia Company, the president of which, Mr. H. Bouchayer, was also present. Referring in his speech to the great debt electric science owes to Italy, Dr. Crowley mentioned that the French Government, which had a contract with the Badische Anilin- und Soda-Fabrik (Haber process), had last autumn entered into an agreement with the Casale Company, whose process is to be adopted in the new factory for producing 120 tons of ammonia daily to be erected at Toulouse. The Casale process utilises electrolytic hydrogen, which can be stored in gas holders, and is suitable for use with intermittent power supply or for "off-peak power." There is no need, it is claimed, for the enormous catalyst bombs of Haber which require cooling for several days and reheating to the reactive temperatures. In the Haber-Bosch process, the cost of the hydrogen was said to amount approximately to two-thirds of the total manufacturing cost. The electrolysis of the Casale process also yielded oxygen, and relatively small units could be worked economically. The Casale Company is an international concern, represented in Italy, France, Belgium, Switzerland, Spain, and the United States, and also in England by the Power Securities Corporation, Limited.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams, the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal, respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates, are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lb. to 80 lb. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

THE EFFECT OF GRAIN UPON THE FATIGUE STRENGTH OF STEELS.*

By LESLIE AITCHISON, D.Met., B.Sc., F.I.C., and LESLIE WILLIAM JOHNSON, M.Met.

THE variation between the properties of samples of metal taken in different directions is not found in the strength but in the toughness and the ductility. There appears to be no sound evidence that the maximum stress of steel, when tested in different directions with respect to the grain, varies at all. The evidence as to the influence of the grain upon the elastic limit is vague and contradictory, except in the one respect that it indicates the influence to be very small. On the other hand, the direction of the forging or rolling grain affects very materially the values obtained for elongation, reduction of area, notched-bar test, and capacity to bend. The variations can be illustrated successfully in various ways, but they become very obvious when the ordinary routine mechanical tests are carried out upon materials orientated in different ways with respect to the direction in which the metal has been elongated by either forging or rolling.

For the purposes of the present investigation, a considerable number of materials have been examined. The main series of tests has been made upon a sample of steel which has been investigated in the ingot and then through the various stages of forging, a known reduction in cross-section being made at each step. At each stage of the reduction, the material has been tested on specimens cut parallel to the grain and also at right angles to the grain. Besides the fatigue tests (which have been carried out by the Wöhler method), comparative tensile tests and impact tests have been made, whilst a record has been kept of the macrostructure and the microstructure of the material. In addition to this leading series of tests, other materials have been examined which are of a more obviously commercial nature.

In particular, the examination has included rolled boiler plate, a forged bar of high-class nickel chrome steel, Armco iron, and two varieties of ordinary Staffordshire wrought iron. All these materials have been submitted to the same process of investigation.

It was considered to be of importance that the influence of the grain should be studied upon material in which the production of the grain could be carefully watched and controlled. This made it necessary to commence experiments with unforged steel. It was similarly desirable to determine directly the properites of the unforged material, and therefore to obtain a value for the fatigue strength of steel in the ingot form. This value would provide a suitable criterion for the effect of the forging grain. It was considered very desirable, however, to make a very careful selection of the cast steel. The material which was employed, therefore, was trepanned from a large ingot. The ingot employed was an octagonal one of approximately 28 in. diameter, and from it the centre was removed. The material employed was taken from the lower part of the ingot. The portion which was extracted in this way consisted entirely of equiaxial crystals. It had a diameter of 13½ in. as extracted. The chemical composition of the steel in the trepanned cylinder was as follows: Carbon, 0·28 per cent.; silicon, 0·15 per cent.; manganese, 0·69 per cent.; sulphur and phosphorus, low. As was expected, there was no difference in tensile and notched-bar values between the specimens cut in the two directions from the casting.

The test results obtained from the series of specimens in different stages of forging showed first, the remarkable uniformity in the values for elastic limit, yield point, and maximum stress; secondly, the increasing discrepancy between the Izod value obtained from the longitudinal and the transverse specimens; and, thirdly, the regular increase in the notched-bar value in the longitudinal specimens as the forging progresses in amount. Whereas the Izod impact value of the longitudinal specimen of the third forging after normalising was 74 ft.-lb., that of the transverse specimen amounted to only 29 ft.-lb. In the case of the first forging the figures were 34 and 27·3 respectively. The fatigue tests on all the specimens were made by the same methods. The Wöhler type of loading was employed throughout, and the fatigue values were obtained by the direct endurance method. The general trend of the results was definitely to show that there was not a very large difference between the fatigue strengths of specimens taken parallel to, and at right angles to, the grain of the material, but that in all instances the difference was in favour of the longitudinal material. The discrepancy between the longitudinal and transverse strengths was not so great as has been suggested. It is worthy of notice that even the transverse specimens have a kind of "longitudinal" grain. Instead of the fibres of the steel that compose the grain being cylindrical threads, they appear to be more or less flat and of the nature of ribbons.

The first two materials of a definitely commercial nature that were tested consisted of first a portion of boiler plate, and second a forged slab of nickel chrome steel. The boiler plate material was delivered in the condition in which it would normally be used, and therefore no further heat treatment was given to the metal prior to testing. Tensile and notched-bar tests were carried out upon the steel in the longitudinal and transverse directions, and as has been noticed in connection with the previous series of forged specimens, the greatest difference in properties between the longitudinal and transverse sections was shown by the notched-bar test. The other mechanical tests on the material did not show any very marked differences. The fatigue tests showed that there was no noticeable difference in the fatigue properties of the material in directions parallel to, and at right angles to, the grain of the slab.

The nickel chromium steel slab had the following chemical composition:—Carbon, 0·39 per cent.; nickel, 3·53 per cent.; chromium, 0·63 per cent. The material was cast in an ingot having a cross-section of 17 in. by 15 in., which weighed 35 cwt. This was brought down in the blooming mill to a finished section of 12 in. by 7½ in. After discarding from the top and the bottom, a billet approximately 8 ft. long was left, and from this billet the section used in the present investigation was cut. The specimens for the mechanical tests, cut out in the longitudinal and transverse directions, were then heat-treated as follows:—Hardened in oil from 830 deg. C., tempered at 675 deg. for 30 minutes and quenched in water. On this material there was a distinct difference between the elastic properties of the metal when tested in the two directions. The elastic limit of the longitudinal specimen amounted to 42·8 tons per square inch and that of the transverse specimen was 27·4 tons. Corresponding figures for reduction of area, per cent., were 61 and 35·7 respectively. As before, the notched-bar test showed up the difference in toughness rather more completely than did anything else. Izod impact values were as follows: longitudinal, 57 ft.-lb.; transverse, 18 ft.-lb. Once again there was no very marked difference between the fatigue properties of the metal tested in the two directions.

The next material worked upon was Armco iron. This was not used in the condition as received, but all the specimens were normalised at a temperature of 960 deg. C.

The mechanical tests showed that there was a distinct difference in toughness between the longitudinal and the transverse specimens. The results for reduction of area also indicate some measure of difference in the properties of the material in the two directions. These latter figures were 80·3 per cent. for the longitudinal and 67·8 per cent. for the transverse specimen.

The specimens for the fatigue tests were normalised as described, and the results obtained upon the specimens in the two directions were practically identical.

A sample of South Staffordshire forged wrought iron containing 0·273 per cent. of phosphorus showed a very marked difference in mechanical properties between the longitudinal and transverse specimens, this difference extending to the maximum stress of the material. This difference was sufficiently great to be interesting, but was not unexpected in view of the nature of the material.

Surveying as a whole the results that have been obtained, it would appear that steel or iron is not quite so strong in fatigue when stressed in specimens whose axis is at right angles to the grain of the material as when stressed in specimens in which the axis is parallel to the grain of the material. The difference in strength between the two directions is, however, not very great. The maximum difference observed in the experiments that have been carried out is 16·7 per cent.

* Paper read before the Iron and Steel Institute, London, on Thursday, May 7, 1925. Abridged.

THE THOMAS GRAY MEMORIAL TRUST.—It is with no small pleasure that we record that a permanent memorial is to be founded to one of the most energetic of the former chiefs of the Marine Department of the Board of Trade. Under the will of the late Mr. Thomas Lowe Gray the Royal Society of Arts was lately appointed residuary legatee, for the purpose of founding a memorial to his father, Mr. Thomas Gray, C.B. It is anticipated that the sum available for the Trust will be 7,000*l.*, and the prescribed objects are "the advancement of the science of navigation and the scientific and educational interests of the British Mercantile Marine." A scheme is now in active preparation by the council of the society. Thomas Gray, it may be mentioned, was born in 1832, and entered the Board of Trade at the age of 19 years as a boy clerk. Before long he was put onto responsible work, and he showed remarkable ability and thoroughness in finding solutions for the difficulties he encountered. His merits were fittingly recognised when he was made Head of the Marine Department at the early age of 37 years. Throughout the 'seventies and 'eighties of last century, when our shipping was developing at a very rapid rate and the Board of Trade systems of regulation and control were being put into shape, he was in full charge of the department.

STRAIN DETECTION IN MILD STEEL BY SPECIAL ETCHING.*

By J. DUDLEY JEVONS, B.Sc.

Part I.—Of the several methods of strain detection discussed in the paper upon "The Detection of Strain in Mild Steels," by Turner and Jevons (see page 588), the only one, with the possible exception of X-ray examination, which gave any promise of adaptability to practical everyday use appeared to be some etching process such as that originated by Dr. A. Fry, of Essen.

This process was briefly as follows. Specimens prepared as usual for microscopic or macrographic examination—special care being taken to avoid distortion by vigorous grinding or polishing—are given a short low temperature annealing at a "suitable" temperature; half an hour at 200 deg. C. being suggested. They are then etched in one of the following solutions until the desired result is obtained, which for macrographic etching is usually in five to twenty minutes.

No. 1 Solution. For Macrographic Etching.

120 cubic centimetres concentrated hydrochloric acid.
100 cubic centimetres water.
90 grammes crystallised copper chloride.

No. 2 Solution. For Microscopic Etching.

40 cubic centimetres concentrated hydrochloric acid.
30 cubic centimetres water.
25 cubic centimetres ethyl alcohol.
5 grammes crystallised copper chloride.

In macrographic etching the specimen is rubbed with a rag moistened with solution and dipped in powdered copper chloride. The specimen is dried without rinsing in water, washed in alcohol and again dried. The etched pattern consists of dark and light bands. These bands appear where a disturbance of the crystals has taken place, and it is possible to distinguish under the microscope whether the difference producing the dark lines is due to disintegration of the crystals, deformation of the crystal boundaries, or slipping of the crystal surfaces. These lines have only been obtained on mild steel, and not on all mild steel with the same distinctness.

This process appeared quite simple and straightforward, but after working for six months and examining hundreds of specimens made from very many different steels without obtaining any trace of the desired markings, the author was completely baffled, especially as many of the steels tried were of practically the same chemical composition as those upon which Dr. Fry had obtained good results. Mr. T. H. Turner therefore communicated with Dr. Fry, who very kindly exchanged a sample of his steel for one of the author's. On etching the piece of German boiler plate thus obtained, the author etched out the characteristic markings in less than a minute, showing that the method of etching with which he had so far been unsuccessful was correct for suitable steels. Subsequently, Dr. Fry wrote saying that he had obtained faint markings on the English sample after twenty hours' immersion. The longest immersion the author had given specimens was six hours, as after this a thick pasty deposit always formed on the specimen, and the original paper mentioned twenty minutes as the maximum time required.

Specimens of English steel were subjected to a prolonged etching, and after 15 hours, traces of the characteristic markings began to appear, a satisfactory etch being obtained after 60 to 80 hours' immersion. Some steels, however, still failed to give markings after a week's etching, while on others the distinctness of the figures varied considerably, and a careful study of the factors influencing the etching process was therefore made. It should be mentioned that throughout the whole of this paper all remarks refer to macroscopic etching unless otherwise stated.

1. *Type of Steel.*—Steels having marked segregation lines due to rolling do not as a rule give clear strain-etch figures, and beyond the fact that a carbon content below about 0·3 per cent. is apparently essential, no connection has yet been discovered between the chemical composition of steels and their ability to strain-etch satisfactorily, but it is evident that previous heat treatment has a marked influence in this connection.

2. *Composition of Solution.*—Very many other etching solutions, with and without colloidal additions, have been experimented with during the last 18 months, but the peculiar strain-effect figures have never been developed satisfactorily by the present author with any solutions except such as contain copper chloride.

3. *Temperature of Preliminary Annealing.*—Experience had shown that the range of time and temperature for annealing those steels upon which markings could be developed was fairly wide, but some definite information on this point was nevertheless desirable. Accordingly, a series of six flat notched tensile test-bars of similar size and shape was made, and each bar

* Paper read before the Iron and Steel Institute, London, on Thursday, May 7, 1925. Abridged.

strained to the same extent (5 per cent. elongation on 2 in.). The six bars were then annealed respectively at 100 deg. C., 200 deg. C., 300 deg. C., 400 deg. C., 500 deg. C., and 600 deg C., in an electric muffle for three-quarters of an hour, after which they were prepared in the usual manner and etched together in the same bath. Little difference could be detected in the clearness of the markings on the bars annealed at 200 deg. C., 300 deg. C., and 400 deg. C., but on those annealed at 100 deg. C., and 500 deg. C., the figures did not develop so quickly, and were, especially on the latter specimen, much fainter, although still perfect in detail. The bar annealed at 600 deg. C., showed only faint traces of strain markings, with imperfect detail. The specimens were made from a typical mild steel, and the results show that for this material a useful annealing range exists between 200 deg. C., and 400 deg. C., while annealing at 600 deg. C., prevents the formation of satisfactory figures.

4. *Degree of Strain in the Steel.*—General observations suggested that, provided permanent deformation had actually occurred, the degree of distortion in specimens had little influence on the quality of any markings which might be developed by etching.

To confirm this theory two series of flat notched tensile test-bars were made from two different steels. The five bars of one series were strained respectively to the yield point 2½ per cent., 5 per cent., 7½ per cent. and 10 per cent. (fracture) elongation, all on 2 in., and the three bars of the other series to the yield point 7½ per cent. and 12½ per cent. (fracture) also on 2 in. All the bars were then annealed at 200 deg. C., for three-quarters of an hour, prepared as usual, and etched in one bath. No difference could be observed in the quality of the markings on any of the bars in their respective series, although the markings on the bars which had been strained to their yield point took slightly longer to develop.

5. *Time of Etching and Method of Manipulation.*—The length of time during which specimens must be immersed in the etching bath in order to produce satisfactory markings depends on four things—temperature of bath, amount of etching solution per unit area of steel surface, frequency of agitation of bath, and etching properties of the steel undergoing treatment. The effect of temperature is dealt with separately in the next section. With regard to the second factor, plenty of solution is essential, as it is used up rapidly. During etching the colour of the bath turns from green to brown, and when a deep sepia tone has been attained the rate of etching is so slow as to render a change of solution advisable. Different steels need different amounts of solution, but as a very rough indication the use of a litre of No. 1 solution for every 30 sq. in. of steel surface exposed may be suggested. If the etching process be carried too far detail is lost, fine markings disappearing completely, although differences in level of as much as a millimetre may be developed on the surface of the specimen after a week's immersion. Using the proportion of solution to steel just mentioned, the author obtains good results in from 60 to 80 hours if the bath be kept well stirred.

6. *Temperature of the Etching Bath.*—It was thought that the time of etching might be shortened by raising the temperature of the bath. Specimens were, therefore etched at 30 deg. C., 50 deg. C., 80 deg. C., and 100 deg. C., but it was found that although depth of etching and vigour of attack certainly increased as the temperature of the bath rose, selectivity of action on strained and unstrained metal decreased rapidly. The author is of opinion that for all ordinary work the best compromise between a fine etching and a reasonable time of immersion is obtained with a bath at room temperature.

7. *Preparation and Condition of Surface of Specimen.*—Provided reasonable care be taken and a sharp tool used for the preliminary preparation of the surface, no special precautions are necessary. A method successfully used by the author is to finish off a specimen with light cuts from a milling cutter and remove the resulting burnished surface by immersing the specimen for a few minutes in dilute nitric acid. After washing, the specimen may be placed directly in the etching bath. All the tedious operations of filing, grinding, and polishing are eliminated.

Part II.—The figures developed on steel surfaces by the etching process described in this paper consist of dark areas and lines composed of permanently deformed metal. By the examination of sections and of the sides of specimens it has been definitely proved that :—

1. There is an abrupt change in hardness on crossing any line in the figures dividing light and dark areas. Impressions taken with a 1mm. ball as close as possible on either side of a dividing line show a difference of as much as 50 Brinell hardness numbers, the darker or distorted metal always being the harder.

2. The etched lines correspond exactly with any Lüders lines produced on the surface of the specimen.

3. There is an actual reduction in the cross-sectional area of a specimen wherever these bands occur.

4. The markings produced by etching are really the sides or surface evidence of blocks of permanently deformed metal, which have been named, in the companion paper to this, "distortion wedges."

These wedges are rectangular in section, and although in many specimens they appear as parallel-sided bands, in their incipient stages of development they always appear as slightly tapered wedges. They originate from points of greatest stress, and increase much more rapidly in their length than in their width of base. If the base be straight, as on a rectangular bar, the wedge will grow straight, but if the base be curved, as when the generating point lies on the edge of a round hole, the wedge will be curved.

It may be argued that such strain figures as are shown are of little practical assistance to the engineer and designer, as once permanent deformation has occurred in a piece of metal the system of stresses present therein is at once altered. This, of course, is perfectly true, but for small amounts of deformation the stress system will not vary to a marked extent, and the etched figures may be taken as a fair indication of the stresses present in a specimen. In any case, the fact that distortion wedges always start from points of greatest stress should in itself prove of value. When considerable distortion has occurred discretion must be exercised in relating resulting figures to original stresses.

Strain Figures on the Conventional Flat Tensile Test-Bar.—From time to time the surface phenomena known as Lüders lines have been discussed, and many theories explaining the internal mechanism of the yielding, elongation, and fracture of a tensile test-bar have been put forward, but the author has never seen any of them substantiated by visible evidence, and Figs. 1 to 10 should therefore be of considerable interest. Ten flat tensile test-bars of conventional shape are shown, which have been strained, sectioned and etched. When pulled, the bars had a uniform coating of hard mill scale in which very clear Lüders lines were produced, thus enabling the surface deformation of the bars to be watched closely while elongation was actually taking place. Space does not permit the inclusion of photographs of these Lüders lines, but on each bar they correspond exactly with the main lines of the etched figures.

The marks caused by the grips of the testing machine are worthy of note, particularly as all visible indentations were machined off the bars before etching. The main strain-etch figures indicate that in no case has truly axial loading been obtained, and not once in the considerable number of tensile specimens examined by the author has this condition been attained.

On every bar permanent deformation as revealed by the scale markings first became apparent at a shoulder in a band running in a direction at right angles to the longitudinal axis of the test-piece. A few similar bands, or, as they were subsequently shown to be, distortion wedges, then formed (Fig. 1) followed by additional wedges running at an angle of nearly 45 deg. to the longitudinal axis of the bar (Fig. 2). A network of these transverse and diagonal bands, with a lesser set on the opposite diagonal plane, then spread gradually from the shoulders up the test-piece (Fig. 3). This process occurred at both ends, and the two systems of bands usually met about two-thirds of the way up the bar (Fig. 4). Soon all traces of individual lines vanished (Fig. 5), distortion wedges having intersected all over the parallel part of the test-piece, and the distorted area spread gradually out into the shoulders of the test-piece, shooting out tangential lines of increasing size (Figs. 6 to 9), until fracture occurred as the result of necking somewhere in the parallel portion of the specimen (Fig. 10). As explained, these scale markings correspond exactly with the real system of distortion wedges as revealed by etching, and shown in the photographs.

On examination of the etched specimens it was found without exception that if the distortion wedges crossing the surface of the bar at right angles to its length were traced round to the sides of the specimen they ran in a diagonal direction, while those which crossed the surface diagonally were always perpendicular on the sides. From these and other specimens it was evident that distortion wedges always grew along four set planes, as in no case did the inclination of principal wedges to the main axis of the bar depart from these planes by an amount greater than could be accounted for by the physical deformation of the specimen. As a rule wedges formed first on the planes cutting the surfaces of the bar at right angles to its length, next on one diagonal plane, and lastly on the other diagonal plane. The collocation of these planes in relation to the surfaces of a rectangular test-bar are shown by the grey and black threads of the model illustrated in Fig. 11. Present experience indicates that this system of planes holds good for all mild-steel bars of rectangular section pulled in tension but that it is not applicable to round bars and compression test-pieces.

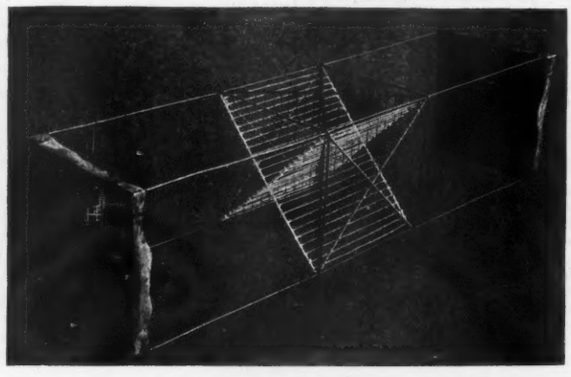


FIG. 11.

Model showing planes on which distortion wedges grow in a bar of rectangular section, strained in tension.

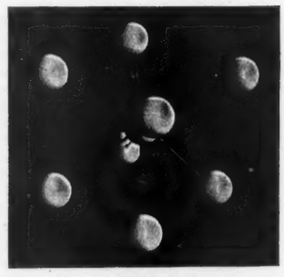


FIG. 12.

Model made by placing a ball wherever six planes intersect in the first model. The skeleton so produced is that of a body-centred cube.

By placing a ball wherever six planes intersect and then removing the latter, the familiar skeleton of the body-centred cube or iron space lattice is obtained (Fig. 12), and although at present the author is not in a position to put forward any definite theory, it seems very improbable that this marked relationship is mere coincidence.

Examination of Figs. 3, 4 and 5 shows that distortion wedges intersected all over the parallel portion of the bars at between 2·5 and 3 per cent. elongation.

Strain Figures on Flat Tensile Bars of Various Shapes.—Figs. 13 to 16 show a series of flat notched tensile bars of similar size and shape strained respectively to the yield point, 2½, 5 and 10 per cent. (fracture) elongation on 2 in. The middle portions only of the bars are shown. Attention must be drawn to the small wedges just forming at the apex of the bottom notch in Fig. 13, but otherwise the figures are self-explanatory.

Some flat bars with edges shaped to represent a screw thread were pulled in tension. Fig. 21 shows

the figure produced by straining one of these to the yield point. As would be anticipated, the greatest stress concentration occurs at the bottom of the notches, but it is interesting to observe that points of equally intense concentration exist where both the last notch and the round shoulder join the parallel part of the bar.

Flat bars, with one central hole, strained in tension respectively to just beyond the yield point and to 2½ per cent. elongation on 2 in., are shown in Figs. 17 and 18. It will be seen that the main diagonal distortion wedges in Fig. 17 and the edges of the deformed areas in Fig. 18 are at the same angle of inclination to the longitudinal axis of the bar.

The figures produced by straining bars of the type illustrated to the yield point, and to 2½ per cent. elongation on 4 in., are shown in Figs. 19 and 20 respectively.

FIG. 25.

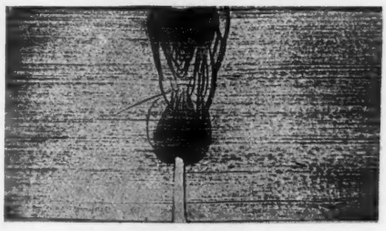


FIG. 26.

FIGS. 25 AND 26. Flat notched bars, bent to and slightly beyond the yield point respectively, sectioned and etched. (Two-thirds actual size.)

Curved boundaries such as can be seen between the four holes in Fig. 20 are unusual. The latter figure is somewhat suggestive of the strain pictures produced by Dr. Coker in his photo-elasticity experiments. The points of original maximum stress concentration may be easily deduced from Fig. 19.

Flat tensile bars with tight peg were pulled in tension. In these specimens a peg was turned down to a driving fit in the central hole of the bar, forced in, and load applied to the peg and one end of the bar. The figure shown in Fig. 22 is produced by straining such a specimen just beyond its yield point. Similar specimens having a loose peg gave very similar strain figures.

Strain Figures on Bend Specimens.—A number of bend specimens, both plain and having different types of notches on one side, have been examined. Each specimen was supported at the ends and prevented from twisting by heavy blocks slotted to receive it, and a ¾-in. diameter roller was forced down on its upper edge directly over the notch. Plain slots, sharp grooves, and Charpy type notches gave practically identical figures, of which those shown in Figs. 25 and 26 are typical. Fig. 25 shows a specimen strained just beyond its yield point, and in this and other notched-bend pieces it is interesting to observe that in all cases wedges start from the sides of the notch and not from the apex, and that deformation of the bar always occurs first underneath the roller on the side remote from the notch. Such specimens may, however, give different results when strained by impact. Fig. 27 shows a plain bar bent just beyond its yield point, and Fig. 28 a similar bar bent somewhat more. In the latter, the existence of a neutral axis is demonstrated very clearly.

Strain Figures Produced by Drifting.—Holes drilled in a steel plate were enlarged by having a hardened steel peg, tapered 0·025 in. per inch, forced into them by repeated blows, the plate being supported meanwhile on a flat surface, having a hole just large enough to receive the peg. Fig. 23 shows the strain figure produced by enlarging a ½-in. diameter hole to $\frac{1}{16}\frac{7}{32}$ in. by this method, and bears a marked resemblance to the figure produced by a Brinell impression.

Strain Figures on Compression Cylinders.—At the time of writing very little work has been done on specimens subjected to compressive stresses, but as a matter of interest, Fig. 24 has been included. It shows the figure produced on a sectioned steel compression cylinder, of the shape shown, which has been compressed 2 per cent. of its total height. The difference of inclination to the longitudinal axis of the cylinder of the thin distortion wedges and the edges bounding the central deformed area is particularly interesting.

From the foregoing examples it will be seen that this special etching process is capable of yielding highly interesting results, and that its range of application is extensive. In its present form it is subjected to the very considerable disadvantage that strain-etch figure cannot be produced on all steels, and its usefulness in the examination of actual failures is therefore limited, but, even so, it seems probable that at the present time a designer could obtain valuable information by constructing models from steel upon which it is known that satisfactory markings can be produced, straining

FIG. 27.

FIG. 28.

FIGS. 27 AND 28. Flat bars, bent to and slightly beyond the yield point respectively, sectioned and etched. (Two-thirds actual size.)

and etching them. By suitable modifications to the process it may soon be possible to produce markings on all steels, in which event its already considerable value would be greatly enhanced.

MALAY STATES 1925 RAILWAY PROGRAMME.—Mainly on account of economic considerations, extensions of the eastern branch of the railway through Pahang and Kelantan, in the Federated Malay States, are to be proceeded with during the year 1925. The Government has been asked to authorise an expenditure of 3 million dols. (350,000*l.*) for work from the northern or Kelantan end, and 1 million dols. (116,666*l.*) for operations from the southern, or Pahang, end of the line. With the approval of these allocations the Pahang section should be completed in 1925 without further cost, and on an estimated additional expenditure of 4 million dols. (466,666*l.*) in 1926, and approximately 3 million dols. in 1927, the Kelantan section should be completed in the latter year.

THE OIL TANK MOTOR VESSEL "ATLANTIC."—On March 24 the launch took place from the Armstrong yard at Sir W. G. Armstrong Whitworth and Co., Limited, of the oil-tank motor vessel Atlantic, which is being built to the order of A/S Dampskibsselskabet Atlantic, Norway. Designed to carry 10,300 tons of oil on a mean draught of 26 ft. 5 in., and travel at a speed of 10½ knots when fully laden, the vessel has an overall length of 455 ft. and a moulded breadth and depth of 57 ft. 2 in., and 33 ft. 11 in. respectively. The Atlantic is of the two-deck type with poop, bridge, and forecastle, two masts, upright stem and elliptical stern, and is being built on the "F. K." Transverse System of partitioning, under special survey and to the requirements of the British Corporation Classification. The oil cargo will be accommodated in 11 main compartments. Two pump rooms are situated fore and aft of amidships. The cargo pumps are three in number and the pipes will be arranged to permit of each tank being loaded or discharged independently of the others. The propelling machinery, constructed by the builders, consists of a reversible single-screw Armstrong-Sulzer Diesel engine, having six cylinders and working on the single-acting two-cycle principle. A b.h.p. of 2,250 will be developed at about 110 revolutions per minute. Air under pressure will be supplied by 2 three-stage air compressors driven by cranks and connecting rods from an extension of the main crankshaft. The cross bunker at the forward end of the machinery space and the fore deep tank can accommodate oil fuel, a pump being provided for transferring the oil to the engine. Steering gear of the electric hydraulic type will be fitted direct to the rudder head and the latter controlled from amidships by telemotor gear. All the engine-room and deck auxiliaries are steam driven, steam being supplied by marine-type tubular boilers. The double bottom of the ship provides space for the carriage of feed water required in connection with the steam plant.

VAPOUR PRESSURES OF LIQUID FUEL MIXTURES.

THE vapour pressure of a liquid fuel is an important factor in several respects. The loss involved in the handling and storing of the fuel, the internal pressure developed in containers and tanks, the fire risks and the ease with which the liquid is vapourised in the carburettor all depend upon the vapour pressure. The presence of air and other gases, methane, helium, &c., in oils, may raise the vapour pressure to a very considerable extent, and render the determination of the actual vapour pressure of the liquid a matter of difficulty. In the case of pure liquids or of solutions of constant boiling point the gas may be boiled off. With natural oils and motor fuels this is not possible, because the composition of these liquids changes while they are being distilled.

Mr. J. Stanley Lewis, B.Sc., of the Royal Naval College, Greenwich, who read a paper on the "Vapour Pressures of Binary and Ternary Fuel Mixtures" before the Institution of Petroleum Technologists recently, overcomes the difficulty by evaporating the fuel in a kind of Torricelli vacuum, his apparatus being a modification of that which Sorel used in his studies of alcohol engines. By raising the mercury basin and opening a stopcock at the top of the vacuum tube, he expels the gas (and the vapour) first liberated and then determines the vapour pressure of the liquid. Traces of moisture also raise the vapour pressure, and they cannot be removed by means of calcium chloride; phosphorus pentoxide or metallic sodium must be used. Water being immiscible with benzene and petrol, the vapour pressure of a mixture of hydrocarbons with water should be the sum of the partial pressures of the constituents at the particular temperature. This Mr. Lewis confirmed by experiments made at temperatures ranging from 0 deg. C. up to 50 deg. C. When substances were partially miscible, he pointed out, the pressure might be raised on mixing the liquids, or it might be lowered until they separated into two phases; once that stage was reached the further addition of one component did not alter the concentration of each phase, but only its relative amount, provided the temperatures were kept constant. For completely miscible binary mixtures, Konowalow has shown that the vapour pressure might lie between those of the components, or be higher than that of either component (minimum boiling-point mixture), or be lower than that (maximum boiling-point mixture). Mr. Lewis found in blending petrols of high gravity or low vapour pressure with paraffin hydrocarbons of low vapour pressure that the resultant vapour pressure did not differ much from that calculated by the mixture formula.

As regards mixture of paraffins and naphthenes, or polymethylenes, open-chain compounds of the general formula C_nH_{2n}, but constitutionally different from olefines, which are common in Russian and Californian petroleums of asphaltic base, Mr. Lewis observed that their vapour pressures might also be calculated by the mixture rule, probably because the two classes of molecules did not associate much, provided the differences in their boiling points were not great. But the presence of aromatics (benzene, &c.) undoubtedly raised the vapour pressure above the calculated figure in benzole-petrol mixtures. When untreated cracked spirits were blended with other types of hydrocarbons (paraffins, naphthenes or aromatics), the vapour pressures observed were little higher than those calculated for small concentrations of paraffins and napthenes, but the reverse held for large concentrations and for aromatics which always gave high values; yet the discrepancies were not great on the whole. Alcohol-benzole mixtures are always of the ternary (not binary) type, owing to the presence of water in the alcohol, which makes the liquids only partly miscible. Mr. Lewis found petrol and alcohol of 98 per cent. miscible in all proportions, but the 95 and 90 per cent. alcohol mixtures separated into two phases. By adding benzene to such mixtures, with 95 per cent. alcohol, Mr. Lewis obtained homogeneous solutions, approximately of the calculated vapour pressures. But mixtures of petrol with 90 per cent. alcohol, and weaker alcohol, required additions of very large amounts of benzene to produce homogeneous solutions; it took, for instance, 1,000 volumes of benzene to dissolve mixtures of 60 volumes of petrol and 40 volumes of 90 per cent. alcohol.

SHIPBUILDING IN DENMARK.—Whilst the shipbuilding industry labours under a difficult position in a number of countries, Denmark is a favoured exception, and her output of tonnage has materially increased since pre-war times. During the decade before 1914 the average output was 22,000 tons, during the last 5 years it has averaged 60,000 tons; in 1924, 64,000 tons were launched. This is mainly due to the building of motor vessels, in which respect Denmark comes in as third, after Great Britain and Germany.

THE DETECTION OF STRAIN IN MILD STEELS.*

By T. HENRY TURNER, M.Sc., and J. DUDLEY JEVONS, B.Sc.

MANY of the best-known metallurgists and engineers have applied themselves to the subject of strain in metals, directly or indirectly. Nevertheless, it is still impossible or extremely difficult to detect, by ordinary means, strain in mild steel, unless the material has been drastically cold-worked and is severely strained. Reviewing the experimental work carried out by the present authors in the light of such published work as they have been able to consult, they note that the methods of the engineer, chemist, physicist, and metallurgist have all been applied to this problem. Each of these methods will now be considered in some detail. The first three methods suggest the viewpoint of the user of metals, the engineer.

1. *Direct Observation*—"*Lüders Lines*."—On testing, in tension or otherwise, bars which are either very carefully polished or covered with a uniform coating of rust or mill scale, it is observed that as soon as the yield point is reached lines appear upon the polished surface, or the scale begins to flake off. The phenomenon has been studied by many engineers who have observed these "Lüders or Hartmann lines" in the course of tensile testing.

The present authors have confirmed the occurrence of Lüders lines in ordinary hot-rolled mild steels, and, as will be shown later, they have been able to bring out these strain lines with greater detail by special methods of etching. These lines, bands, or, as they undoubtedly are, wedges of distorted metal, occur in all carbon steels, wrought iron, and pure iron, but only in the mild steels are they easily obtainable. Up till comparatively recently proof has been lacking of the fact that these markings on the surface of a strained specimen really indicate wedges of grain disturbance extending, when fully developed, right across the specimen. The photographs shown by the present authors illustrate sections cut through the specimens, and similar results can be produced in the same steel on other sections wherever desired. The continuity of the etch lines down the sides of rectangular specimens, enabling the same wedge of distortion to be seen on all four sides of the specimen, has permitted conclusive proof of the fact that Lüders lines do indeed indicate wedges of distortion.

2. *Direct Measurement.*—The authors have been able to indicate the location of permanently strained areas in certain specimens in a very simple manner. In certain of their early experiments notched flat bar tensile specimens were used to provide severely and slightly strained areas. On filing the surface of one of these specimens, it was noticed that the file did not bite on the central area where the specimen had been reduced in cross-sectional area when elongated under the straining action of the tensile testing machine. This observation might well have been predicted, but as it was new to the authors they made and examined a series of variously notched flat bar tensile specimens. These were of mild steel, machined flat, and before being permanently strained in tension, their surfaces were roughened by dipping in acid in order to increase the contrast produced by the subsequent machining. Instead of filing these specimens, as in the first case, they were all milled with a parallel-sided milling cutter. In this manner a clear definition of the areas reduced in cross-section was obtained by means of what was termed the "dirt" effect; that is, the badly strained parts remained dirty and the unstrained areas showed a brightly reflecting machined surface. Hence by photographing the specimens, after successive light cuts had been removed parallel to the surface of the bar, less and less of the dirty etched areas were retained, until these became merely small circles, showing the

FIG. 1.

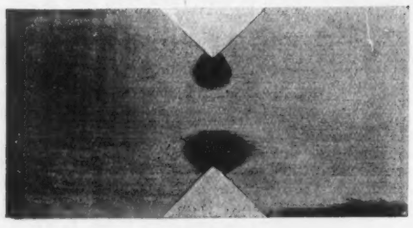


FIG. 2.

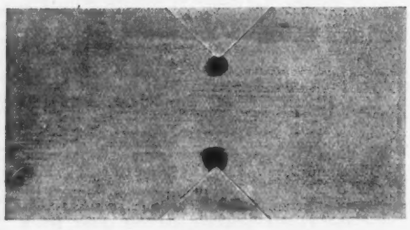


FIG. 3.

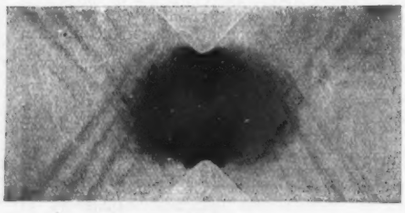


FIG. 4.

Flat notched bar strained in tension to 5 per cent. elongation on 4 in.
Figs. 1, 2 and 3 show successive cuts removed from the surface by milling.
Fig. 4 illustrates the surface deformation map obtained by superimposing and slightly idealising the preceding photographs.

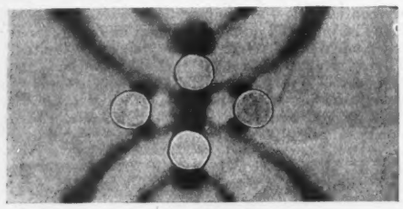


FIG. 5.

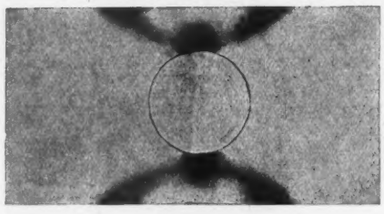


FIG. 6.

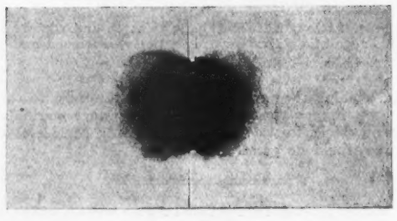


FIG. 7.

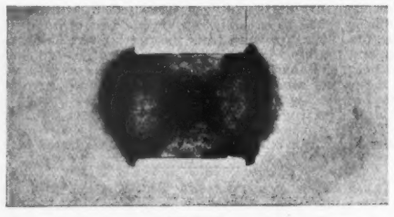


FIG. 8.

Slightly idealised surface deformation maps obtained from flat bars of the shapes shown, strained in tension to an elongation of 5 per cent. on 4 in.

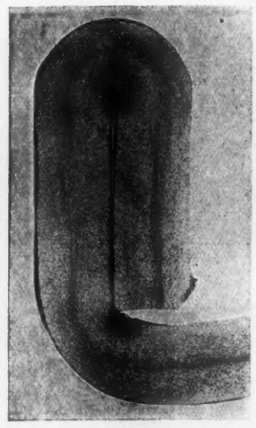


FIG. 9.

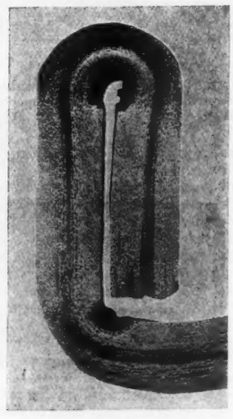


FIG. 10.

Figs. 9 and 10 show a bent specimen sectioned and etched for 10 minutes and 2 hours respectively in boiling 50 per cent. HCl. × 2.

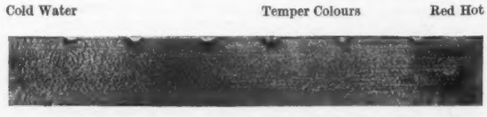


FIG. 11. Right end of bar has been heated to redness before sectioning and etching. Strain markings developed under third indentation from left (water-cooled) end.

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NOTE.—Figs. 1 to 14 have been reduced to two-thirds original size.

concentration of the strain at the point of the notch or at similar points of maximum strain. Figs. 1, 2 and 3 illustrate stages in so treating one of this series of flat bar tensile test-pieces.

Superimposing and somewhat idealising these three photographs, the strain concentration diagram shown in Fig. 4 is obtained, which is somewhat reminiscent of the beautiful coloured illustrations produced by Professor Coker. Fig. 4 is really only illustrative of the intensities of reduction in cross-section in a steel bar pulled beyond its yield point. The whole series of specimens tested in this manner by the authors cannot be reproduced here on account of the limitation of the space available, but Figs. 5, 6, 7 and 8 illustrate the type of result obtained on different shapes of specimen treated in the manner described for Fig. 4. The method may be recommended to students and engineers as surprisingly instructive concerning the influence of holes, notches, and sharp corners.

3. *Hardness and Density Variations.*—Hardness is increased by cold-work, and it has been shown that by means of systematic hardness determinations over a flat surface it is possible gradually to map out the location of the severely strained areas. The scleroscope

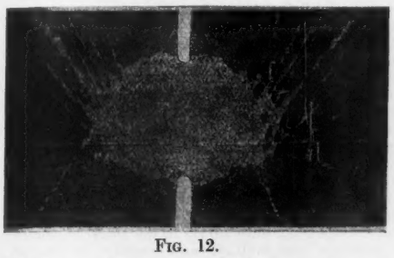


FIG. 12.

Markings in mill scale, or Lüders lines, produced on flat notched bar strained in tension to 5 per cent. elongation on 2 in.

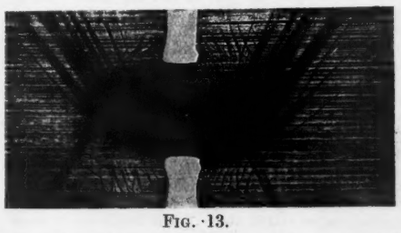


FIG. 13.

The same specimen sectioned and etched with Fry's solution, showing that Lüders lines are the surface evidence of distortion wedges in the metal beneath.

and the small ball Brinell have both been used successfully for this purpose. The present authors have repeated such experiments, and have found the method good, but not accurate as to details, unless great care is observed both in obtaining an excellent surface polish and in conducting the actual hardness measurements.

4. *Analysis of Gases evolved on Solution.*—Turning now to the methods of chemistry, it is interesting to note that permanent strain in metal influences the chemical properties of metals, and that the gases evolved from strained and unstrained metal vary in accordance with the amount of strain. Although strain may be indicated by this method, the location and distribution of the strain in a piece taken from service would be next to impossible, in the view of the present authors, since a specimen slightly strained all over might easily give the same result as one severely strained locally. They have, therefore, made no experiments in this direction.

5. *Solution Potentials.*—It is probable that the corrosion of steel in an acid is either dependent upon minute electric currents, or at least aided by them. In general, it is found that severely strained metal is corroded more readily than that which is unstrained. For example, if after fracturing, a mild steel tensile test-piece be placed in hydrochloric acid, it will be noted that the $\frac{1}{2}$ inch or so of the steel nearest to the fracture, namely, the necked portion, will be corroded away much more rapidly than the remainder of the specimen.

Such observations suggested that the measurement of solution potentials over the surface of a partly strained specimen might be a means of mapping out the location and intensities of the strain in the steel. Attempting to do this with a needle-point as the searching electrode showed that the current varied with the distance of the needle-point from the surface tested. A searching electrode was therefore made by fusing a platinum point into a small inverted glass cup, so that when the rim of the cup was pressed upon the specimen the platinum point was held approximately 2 mm. above the surface of the steel. When searching, electrode and specimen were simultaneously connected by wire to a millivoltmeter about 20 millivolts were registered. Unfortunately, this varied as the searching electrode was moved away from the wire soldered to the specimen, and thus masked differences which have been produced owing to local strains. To overcome this the searching electrode was attached by string so as to move in an arc about the point of connection with the other wire. No change in E.M.F. was observed as the electrode was moved from strained to unstrained material, and any difference must have been less than 0·1 millivolt. Possibly these experiments should be repeated without using the soldered joint for the other wire, but polarisation effects have also to be considered. As soon as the millivoltmeter needle ceased swinging it began to creep back again, owing to polarisation. By using the potentiometer and only allowing current to flow when the key was pressed, polarisation difficulties were lessened, but even so, no definite results were obtained, readings under 0·1 millivolt being

FIG. 14.

Flat notched bar, strained to 5 per cent. elongation on 4 in., sectioned and etched. Oblique lighting reveals depth of etching.

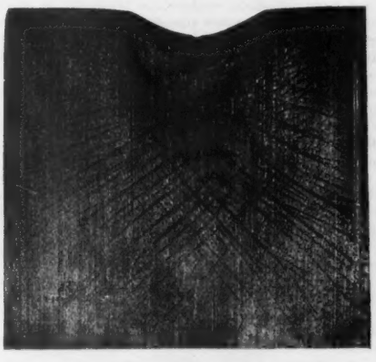


FIG. 15.

Etched section of mild steel strained by indentation and heated to produce abnormal grain growth.

NOTE.—Deformation wedges extend farther than the area of abnormal recrystallisation. (Actual size.)

erratic. Despite the lack of success with this method it still appears worthy of consideration, and should be capable of producing interesting results if experiments were conducted using many different electrolytes.

6. *Corrosion Effects.*—Some of the earliest experiments made by the authors during the present work related to the effects of the common acids upon strained steels. Bent specimens of Armco iron and mild steel were sectioned, polished, and etched with various concentrations of hydrochloric, nitric, and sulphuric acid, and it was found that although a more or less selective action occurred with all these acids, 10 per cent. nitric acid and 50 per cent. hot hydrochloric acid gave the best results. In the early stages of etching this selective action resulted in a darkening of the strained areas on the inside and outside of the bend, as shown in Fig. 9, which illustrates a bent specimen of mild steel rod etched for ten minutes in boiling 50 per cent. hydrochloric acid. Fig. 10 shows the same specimen etched for two hours and rubbed lightly on emery-paper. It will be seen that marked selective action has occurred. The centre line is due to segregation. With specimens made from Armco iron slight darkening occurs in the early stages, but no deep selective etching takes place. A number of broken tensile test-bars of different steels were sectioned and etched in a similar manner, but beyond the fact that the metal near the fracture became very deeply corroded, no selective action was apparent.

The effect of adding a colloid to the etching solution was tried. Using a small addition of starch solution a slightly increased contrast, due to the apparent whitening of the lighter areas, was produced on the bent specimens referred to above, but this disappeared as soon as deep etching began. Adding methylated spirit to the etching solution reduced the vigour of the attack, but did not increase the selectivity of action.

So far the results obtained appear to show that although etching specimens with the common acids does sometimes give a very general indication of distorted areas, no real strain figures of practical utility, such as are produced by the process later described, can be obtained by means of mere rapid corrosion by acids.

7. *Electrical Resistance Variations.*—The influence of stresses and strains upon the electrical resistance of a metal has been studied, and might possibly be used practically to detect strains. However, in experiments which the authors carried out, using two contact points, which were connected with a source of current and with apparatus for detecting slight differences in current flow, and could be moved so as to complete the circuit by loading the specimen under test wherever desired, it was found that contact variations and change in thickness of the specimen masked any variations of value in strain location.

8. *Magnetic Effects.*—It is just possible that local strains might be detected in a mass of steel, owing to differences which strain produces in the magnetic properties of the metal. The detection of a minute crack by means of iron dust brushed over the surface of a magnetised article requires for its success as fine a polish of the surface as possible.

9. *X-Rays and Miscellaneous Methods.*—X-Ray investigation is doubtless a most instructive and valuable method of examining strained metal, in that it may reveal such distortion of the space lattice as may prove to be the basic characteristic of strain in metals. Reference to the abstract sections of recent journals shows that very much valuable research work has been done in this connection by workers in various countries, but the present authors have devoted no time to this study as a method of strain detection, for, although they are fully alive to its very great importance, it is not at present capable of adaptation to commercial investigations, and demands costly apparatus, skilled operators, and thin specimens for the production of good results.

The authors have experimented to some extent with a further group of miscellaneous methods, such as plating with copper, amalgamation with mercury, and etching with dry hydrochloric acid gas, but no promise of successful strain detection was obtained in such directions. The following and concluding group of experiments of a metallurgical nature have proved decidedly more instructive.

10. *Microscopical or Metallographic Methods.*—Numerous workers have, by means of a microscope, observed the slip-bands which are produced in individual grains, the elongation of equiaxed grains, the breaking into smaller grains of one big crystal and the grain boundary ruptures, all of which may and do sometimes occur in the straining of metals. Attempts have been made to correlate the magnitude of the deformation of a metal mass with the microscopical changes in structure visible on polished and etched sections. Very severe strain is easily recognised in this manner, and the grain distortion or elongation encountered immediately below a machined surface is familiar. By examining a tensile test-piece, however, it is soon discovered that minute permanent strains are not readily detected.

Certain etching reagents darken strained areas in mild steels to a greater extent than they do the relatively unstrained areas. It is, however, extremely difficult to detect the small differences in the amount of strain within, say, 5 per cent. elongation, by means of ordinary microscopical examination. The special methods of etching to be described later do permit of this, and enable strain to be detected and located as soon as the yield point is reached, and before, say, 1 per cent. of elongation has been produced, whereas ordinary microscopical observation would not differentiate between test-pieces strained just below and just above the yield point.

Microscopical examination of the material in the distortion wedges appears to show at least three types of disturbance. The crystal grains exhibit slip, break up into smaller grains, or part from one another at the grain boundaries. The first is the more common, and probably the more important or fundamental phenomenon. Slip may be observed in every or almost every grain in the distortion wedges, but crystals exhibiting slip may also be seen in some places in the apparently undistorted material between the distortion wedges.

11. *Recrystallisation.*—The peculiar growth of certain grains at the expense of others, which occurs when strained mild steels are annealed within suitable limits of temperature, has been studied in recent years by

many workers. The conditions governing such abnormal grain growth are somewhat better understood now as a result of their labours, but the use of this phenomenon to detect the location and magnitude of strains is at present outside the field of practical utility. Photographs of abnormal grain growth do not illustrate the lines of flow in the deformation of the iron, nor do they fix all Lüders lines in terms of crystalline structure, as may be seen in Fig. 15, which shows deformation wedges reaching far below a recrystallised area of abnormal grain growth.

12. *Special Methods of Etching.*—The successful use of special methods of etching for the detection of strain in steel is apparently quite a recent development. Strauss, in 1905, noted lines on a piece of cold-worked boiler plate etched in copper ammonium chloride solution. Fisher, in 1913, found similar lines near the sheared edges of sheet iron strips used as anodes in the manufacture of electrolytic iron. All such marks were more or less valueless until Fry, in 1921, discovered a method of etching which showed such lines on sections, and upon which the present authors have spent much time. It is true that up till now the authors have not been able to produce such lines on all carbon steels, but they have definitely identified Fry lines with Lüders or Hartmann's lines. Most of the German work appears to have been upon pieces strained in compression or bending. The present authors have found similar markings in tension, bending, compression, and shock-strained mild steels.

Figs. 12 and 13 show the same elongated testpiece. Fig. 12 is a photograph illustrating lines in the surface scale, just as shown on similar test-pieces by Gulliver, and Fig. 13 is a photographic reproduction of the etch lines produced on a section cut parallel to the surface shown in Fig. 12. The depth to which such lines are etched out is clearly seen in Fig. 14, which was photographed with very oblique lighting. For the production of such lines Fry used a strongly acid solution of copper chloride, and rubbed the specimen from time to time with a wad. In principle this method has proved most successful in the authors' own work. Their experience in this direction is described more fully in Mr. Jevons' paper, which is concerned more particularly with this part of the subject (see page 585).

Briefly, it may be said, however, that distortion wedges are not indicated macroscopically by etching alone. A low temperature annealing in the range 200 deg. to 600 deg. C. or thereabouts appears to be necessary in all cases, since strained mild steel does not show distortion etch marks unless so annealed before etching. This fact may be illustrated by Fig. 11, which shows a piece of mild steel strained in six places by similar indentations and then heated to a red heat at one end, and maintained so heated for twenty minutes while the other end was kept cool in water. Temper colours commenced at the third indentation from the hot end. After milling off the surface, the bar was etched. It will be seen that etching out of the badly strained areas and of the distortion wedges has only occurred in one particular part of the bar, thus indicating that the temperature to which this steel should be heated before etching for strain markings is below that at which temper colours are produced.

Heating within a wider range than here indicated may cause the markings to be etched out, but within a comparatively narrow range of temperature only are the clearest results obtained. Sometimes heating to 600 deg. C. appears to make them vanish, but in other cases heating for several hours at 700 deg. C. does not remove the tendency to etch out along distortion lines. It is possible to obtain these etch markings upon articles which have not been especially heated in the laboratory, but which have been suitably heated during manufacture or service life. Thus the punching of a rivet hole leaves local strain in the material, which latter is sometimes low annealed by the hot rivet, thus giving the combination necessary for the direct etching out of these deformation line markings. Hot galvanising or heating preparatory to tarring of cold-worked articles, finishing rolling at too low a temperature, or service in heated mechanisms, all give similar results.

Observations they have made enable the present authors to state that in straining a four-sided specimen of mild steel in tension distortion wedges begin to advance across the section as soon as the yield point is reached.

At first these narrow wedges of distorted material only advance along two planes at right angles to one another. At a later stage, when further straining occurs, the distortion wedges also appear upon two other planes roughly at right angles to one another and at 45 deg. to the first two planes. All four planes, along which the distortion wedges advance, are roughly at 45 deg. to the longitudinal axis of the specimen. Conformity to any constant angle is prohibited by the constant redistribution of stress which any local distortion of the metal structure entails. The distortion wedges are straight sided or curved sided. In cases where the stress has been applied from a curved object, as, for example, in the Brinell test or in drifting out a circular hole, the distortion wedges starting from the source of strain have curved bases and curved sides.

The specimen is reduced in cross-section wherever distortion wedges appear after elongation. The microstructure of the metal in such wedges exhibits slip, crystal breakdown, or grain boundary failure when seen under the microscope, after suitable treatment. Lüders or Hartmann's lines are the surface signs of distortion wedges. Wedge is here used advisedly, for the distortion is neither a surface phenomenon nor mass slip along a plane right through the section. The first distortion wedge to appear always starts from the most highly-strained locality, and advances across the section at the same time as it broadens at the base. Rupture only takes place after the distortion wedges have intersected one another all over the area of the failure. Abnormal grain growth does not occur where two distortion wedges intersect, but does occur in the area where more than two such wedges intersect. In the distortion wedges of a flat bar tensile specimen, the metal appears to have started a movement towards the central axes. This result, which somewhat resembles the reduction in section of a piece of rubber when it is stretched, is probably due to crystal slip, which takes place in three directions towards two axes of the specimen—that is, one slip direction towards the apex and two other directions parallel to the faces of the wedges, and opposed to one another. For other shapes of specimen distortion, wedges form in keeping with the geometrical arrangement of the stresses.

It is not clearly understood why distorted metal and undistorted metal so often lie side by side, in what almost amount to laminations, or why a second distortion wedge nearly always commences to grow before the first has grown to its full extent. Small ball hardness tests upon carefully-polished specimens have shown conclusively that the distortion wedges are definitely harder than the apparently unstrained metal lying between them. In ordinary commercial hot-rolled bars distortion wedges are produced in greater number, or appear more plainly, when the strain has been produced in the direction of rolling. The etch patterns produced by the same type of strain applied transversely and longitudinally undoubtedly differ in their characteristic forms. Specimens strained after they have been quenched from above 900 deg. C. do not appear to show signs of the distortion wedges, which are obtained upon the same material strained in the "as rolled" or fully annealed condition.

Any connection between low temperature thermal magnetic, and fatigue critical arrest points, blue, brittleness, the critical low temperature annealing which aids the solution of strained areas in the etching of distortion wedges, and possibly abnormal grain growth, have still to be proved.

SULZER TWO-STROKE MARINE ENGINES.—During the year 1924 a considerable development was made in the marine use of two-stroke Diesel engines. Taking the Sulzer type as an example, in addition to the M.S. Aorangi, built by the Fairfield Shipbuilding and Engineering Company, Limited, Glasgow, and fitted with Fairfield-Sulzer engines of 13,000 h.p., mercantile vessels with Sulzer engines were constructed by Messrs. Lithgows, Limited, Port Glasgow; Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle; Rotterdam Drydock Company; Ateliers et Chantiers, Nantes; Cantieri Savoia Cornigliano, Liguria; and A. G. Weser, Hamburg. The works at Winterthur, Switzerland, also built 52 engines of the same type, with an aggregate of 19,500 i.h.p., for submarines, tugs, and small craft.

JOINING INFRA-RED AND ELECTRIC-WAVE SPECTRA.—With the aid of very small Hertz oscillators electric waves of only 0·22 mm. length have been produced which overlap the extreme infra-red rays of wave-length 424 μ (or 0·424 mm.) by an octave. The gap between long light waves and short electric waves has thus been bridged over. The announcement of this achievement was to have been made last summer in the National Academy of Sciences, Washington, by Professor E. F. Nichols, famous for his determination of the radiation pressure of light in conjunction with Professor G. F. Hull in 1903 (which followed the first determination by Lebedeiew); but Professor Nicholls died on the platform. The experiments were described by his colleague, Dr. J. D. Tear, in the Astrophysical Journal of January. The Hertz oscillator consisted of two tungsten wires, 0·1 mm. in diameter, projecting 0·1 mm. from glass tubes. The waves produced had a length of 0·9 mm., and one of the overtones measured had a wave-length of 0·22 mm. These waves passed through a quartz plate and a paraffin lens to an interferometer (mirrors or an échelon built up of brass plates piled upon one another in step) and further to a receiver, a very fine platinum wire or a film of platinum, to measure the energy radiated in a Hull radiometer. In other experiments infra-red mercury-arc rays of wave-length 0·42 mm. were measured, slightly longer than those previously determined by Rubens and Hollnagel; the determination of still longer mercury waves of 0·685 mm. was not quite certain, both figures would be in agreement with the quantum theory.

THE BRITTLENESS OF ELECTRO-PLATED STEEL, AND THE ADHESION OF THE COATING.

THE practice of preventing the corrosion of steel by the deposition of thin electrolytic coatings is regarded with suspicion in the case of steel springs, wires and other articles of small dimensions, because it has long been understood that the treatment renders the steel brittle. The brittleness is attributed to the hydrogen evolved during the electrolysis and adsorbed by the steel. The hydrogen can be expelled again subsequently by heating, but hardened steel might lose its hardness by reheating.

Experiments on the zinc plating of streamline wires, used for bracing structural members on aircraft, were described by Mr. H. Sutton, M.Sc., of the Royal Aircraft Establishment, in a paper on "The Brittleness of Zinc-plated Steel," read before the Faraday Society on the 27th ult. The wires are elliptic in section and are made from rolled rod of medium carbon steel, which is first "patented," *i.e.*, rapidly cooled in air or other media from 850 deg. C., and then swaged by means of special rolls. It is then used without further heat treatment. The wire must have a tensile strength of 64 to 68 tons per square inch and bear five reversals in the bending test. As acid-pickling notoriously favours brittleness, Mr. Sutton cleaned his wires with emery or by sand-blasting before placing them in the bath of zinc and sodium cyanides and caustic soda. The plating did not impair the tensile strength of the wires, but they stood only from 2 to 4½ reversals instead of the 6 or 6½ which they would stand unplated. Variations of bath composition, current density, agitation, &c., made little difference; warm baths (60 deg. C) gave slightly less brittle wires; the addition of various colloids rather increased the brittleness. Wires with a thin coating of zinc 0·0005 in. thick, recovered their ductility slowly in the course of months at ordinary temperature, and rapidly by heating for half an hour to 100 deg. C. in water or air. With thicker coatings of 0·0015 in. and more, the recovery was incomplete after heating to 100 deg. for one hour. Heating of the wire to 100 deg. before plating had no effect, but previous tempering at higher temperatures diminished the brittleness, whilst the cold work of swaging increased it. Plating in neutral zinc sulphate was not injurious, the wire standing 5½ (instead of 6½) reversals, but acid sulphate baths produced brittleness. That the pickling in itself causes brittleness, and that this brittleness will disappear again in the course of a few days, was shown by Ledebur in 1878. But the quick recovery of the zinc-plated wire in boiling water is rather surprising, and probably explained by the thinness of the coating; heating to high temperatures has to be avoided, as we stated above. The brittleness depends upon the adsorption and diffusion of the hydrogen, and hence upon the state of the surface of the metal to be coated.

Another paper read the same evening on the "Adhesion of Deposited Nickel to the Base Metal," by Mr. E. A. Ollard, of the research department of the Metropolitan-Vickers Electrical Company, Limited, was concerned with the method of testing rather than the deposition. The works, Mr. Ollard explained, wanted to know whether parts of high-speed machinery could safely be built up by electro-deposition and for that purpose needed to determine the true adhesion of nickel to a steel shaft. In experiments made at the National Physical Laboratory a collar deposited on a mild-steel shaft had been pulled off by means of a tensile machine. But such a coating would behave rather like a shrunk-on collar, and the experiment would not reveal the true nature of adhesion, which, as Dr. R. S. Hutton subsequently emphasised, was important also for the problems of welding, soldering, &c. Mr. Ollard finished some 1 in. steel shafts, carefully pickling them and then nickel-plated (in a sulphate bath) the flat end to a depth sufficient to grip the deposit in a machine. The deposit was made larger in diameter than the shafts and extended up the length for one quarter of an inch, forming a flange some ¼-in. greater in diameter than the shaft. He then pulled the shaft out or pushed it out by drilling a hole through the deposit for the insertion of a plug. In this way he obtained adhesion strengths of up to 35 tons per square inch. But the results varied; it is, of course, difficult to keep the conditions normal in such tests, as sufficiently thick layers took 250 hours to deposit.

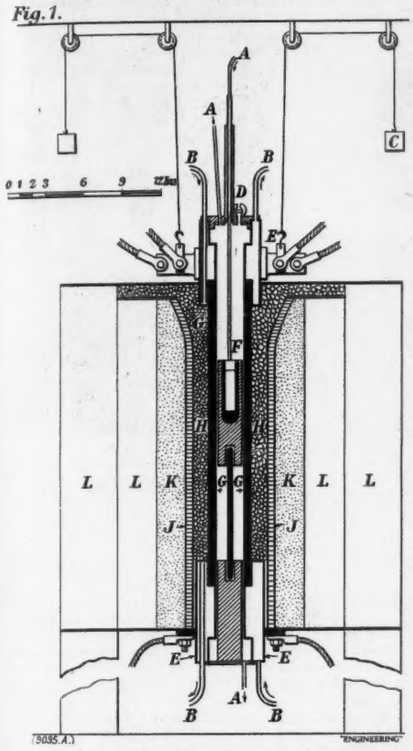
ITALIAN SHIPBUILDING.—There are at present 27 yards in Italy, building 110 ships. It goes without saying that this large number of yards could, if fully employed, produce substantially more tonnage than the country itself could absorb; as a matter of fact, the average annual production during the period 1914–24 only amounts to some 100,000 tons. In these circumstances it is not surprising that the Italian shipbuilding industry is in a precarious condition.

THE INFLUENCE OF GASES AT HIGH TEMPERATURES UPON IRON, AND THE FORMATION OF BLOWHOLES.*

By A. GLYNNE LOBLEY, M.Sc., and C. L. BETTS, M.Sc.

PRIMARILY this investigation was undertaken to test experimentally McCance's explanation of the formation of blowholes in iron and steel. This explanation is based on the assumption that whilst carbon monoxide is easily soluble in solid steel, carbon dioxide is very much less soluble. Both gases are assumed to be soluble in the liquid metal; hence, on solidification, the carbon dioxide would be expelled, forming blowholes. If McCance be correct, it offers an explanation of the effect of the treatment in the open-hearth furnace on the steel, and its importance is, therefore, obvious. While attributing the formation of blowholes entirely to carbon dioxide, McCance explains the presence of other gases in the blowholes by assuming their diffusion from the steel into the already formed cavities.

Fig. 1.



A = gas inlets and outlets. B = water inlets and outlets. C = weight supporting cables, &c. D = window. E = water-cooled end-pieces. F = magnesia (brasque). G = carbon tube resistor. H = charcoal. J = carborundum tube. K = sand. L = firebrick walls.

The experimental method adopted was to melt pure iron in a stream of gas, cool in the same atmosphere and examine in various ways the specimen obtained. After consideration of different types of furnaces, it was decided that the most suitable one for the purpose was an electric furnace, using a carbon tube resistor of the type originated by Hutton and Patterson. Accordingly, a vertical furnace was designed and built, a large carbon tube 3 in. in diameter being mounted in gun-metal water-cooled end-pieces. The diagram (Fig. 1), giving a sectional elevation of the furnace, shows the construction sufficiently clearly for the purposes of this paper without further description. The crucibles were turned out of solid graphite and lined with a brasque of fused magnesia, using a binder of magnesium chloride.

Armco iron was considered to be sufficiently pure for the purposes of this investigation, and was used in the form of round bar, cut off in lengths to suit the crucible.

The gases used in the work were hydrogen, nitrogen, carbon monoxide, carbon dioxide and coal gas. The carbon monoxide was prepared by passing carbon dioxide over heated charcoal, excess carbon dioxide being removed in the usual way. All the gases were dried before use, any oxygen in the nitrogen being removed by means of an alkaline pyrogallol solution. The gas was passed into the furnace through the top tube, which was arranged so that the gas impinged on the surface of the metal before passing to other parts of the furnace. Positive pressure was maintained in order to minimise diffusion inwards through the carbon tube. A small secondary flow of gas was directed into the upper part of the tube to remove fumes and so facilitate observation.

Observations were made through the window in the top, this being specially devised to enable both sides of the glass to be cleaned during the actual experiment. The temperature was measured by means of a Wanner optical pyrometer, which was calibrated from time to time. By careful regulation of the electrical energy supplied to the furnace the temperature was raised and lowered at a definite rate, the maximum temperature in each experiment being maintained for 30 minutes. Fig. 2 illustrates graphically the course of a typical experiment.

For the purpose of checking McCance's assumptions it was only essential to heat the metal to a temperature similar to that prevailing in the open-hearth process; the opportunity, however, was taken of making a series of observations at higher temperatures, up to over 2,000 deg. C., both with carbon monoxide and carbon dioxide.

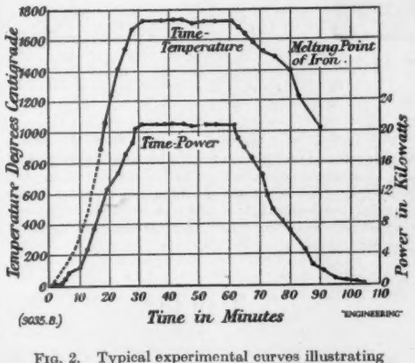


FIG. 2. Typical experimental curves illustrating rates of heating and cooling.

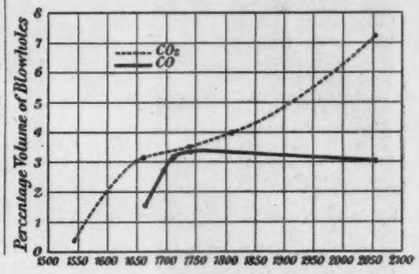


FIG. 3. Blowhole volume/temperature curves with carbon monoxide and carbon dioxide.

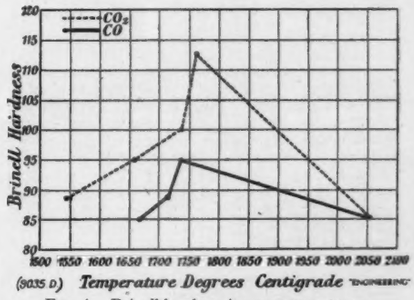


FIG. 4. Brinell hardness/temperature curves.

The crucible, with its charge of metal, about 300 grammes, was placed in the centre of the furnace tube. After passing the gas for a sufficient length of time to ensure the air being completely displaced (confirmed by tests) the furnace was started up, the rate of heating and cooling being standardised, as already stated. The melt was allowed to cool completely in the stream of gas before removal from the furnace.

After visual examination of the treated metal the apparent density was determined, from which the volume of the blowholes was calculated. The specimens were then cut longitudinally, one-half of each being ground, polished, and etched for micrographic examination (alcoholic picric being found to give the best results). The same halves were subsequently finely re-ground, and etched with 20 per cent. sulphuric acid for macrographic examination. On the remaining halves the Brinell hardness was measured, the mean of three determinations on each specimen being taken.

The main results are shown in the table (page 592). The blowhole capacity with the gases carbon monoxide and carbon dioxide over a range of temperature, and the Brinell hardness numbers for the same specimens, are depicted graphically in Figs. 3 and 4. [Figs. 7, 10, 12, 13, 14, 15 and 16, selected from the paper, show the specimens examined in Experiments Nos. 12, 2, 9, 5, 8, 6 and 7 of the Table.—ED. E.]

Notes.—Experiment 20: In this the temperature was not sufficiently above the melting point to bring about absorption of the gas in excess of the solubility in the solid state during the time exposed. Experiments 2, 8, 15 and 27: The specimens were appreciably carburised, 0·2 to 0·3 per cent.; but in all the other experiments the structure was that of a very mild steel. Experiment 5: The soundness of the melt with nitrogen was confirmed by other experiments, which, however, are not given here, owing to the failure of the brasque causing carburisation. A very large grain-size was observed, from 0·25 millimetre to 0·40 millimetre, in the carbon dioxide series, and somewhat larger, 0·27 millimetre to 0·45 millimetre, in the carbon monoxide treated specimens, in both cases the size increasing with the temperature.

These results show that: (1) The blowholes occupied

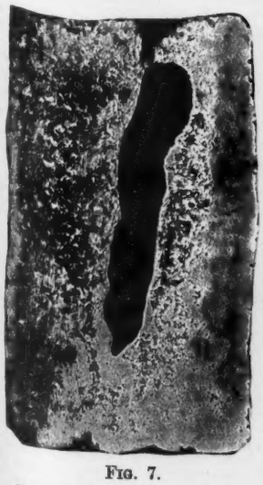


FIG. 7.
Experiment 12. CO_2. 1737° C. × 1·3.

FIG. 10.
Experiment 2. CO. 1694° C. × 1·3.

FIG. 12.
Experiment 9. CO + Fe_2O_3. 1694° C. × 1·3.

* Paper read before the Iron and Steel Institute, London, on Thursday, May 7, 1925. Abridged.

THE INFLUENCE OF GASES ON IRON AT HIGH TEMPERATURE.

FIG. 13.
Experiment 5. N_2. 1700° C.
× 1·3.

FIG. 14.
Experiment 8. H_2. 1694° C.
× 1·3.

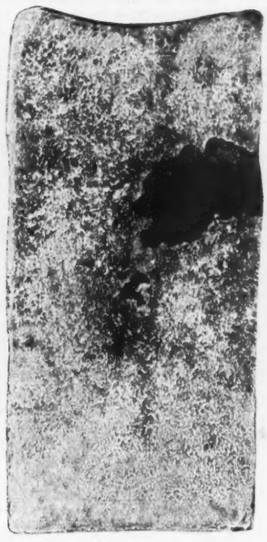


FIG. 15.
Experiment 6. Coal gas. 1700° C.
× 1·3.

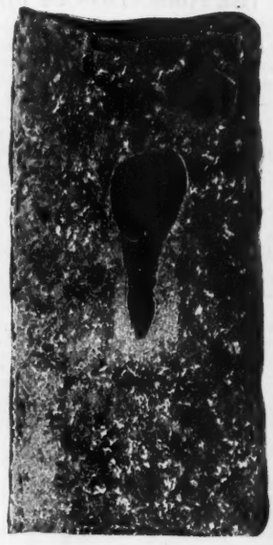


FIG. 16.
Experiment 7. Coal gas + Fe_2O_3.
1694° C. × 1·3.

Experiment No.	Gas, &c. (Fig. 3).	Temperature deg. C (Fig. 3).	Volume of Blowholes. Per cent.	Brinell Hardness No.
20	CO_2	1,546	0·46	89
10	,,	1,657	3·20	95
12	,,	1,737	3·55	100
27	,,	1,810	4·00	113
23	,,	2,054	7·20	85
29	CO	1,666	1·66	85
2	,,	1,694	2·78	122
28	,,	1,715	3·24	89
13	,,	1,737	3·39	95
33	,,	2,054	3·06	85
9	CO + Fe_2O_3*	1,694	5·19	89
5	N_2	1,700	0·64	89
8	H_2	1,694	13·14	129
6	Coal gas	1,700	2·63	107
15	,,	1,737	8·24	89
7	Coal gas + Fe_2O_3*	1,694	4·99	85
16	,, ,,	1,680	4·02	95

* The iron oxide was introduced in the form of F_2O_3, but at the high temperatures would be transformed, first into the magnetic oxide and further into FeO.

a greater volume in the carbon dioxide treated specimens than in those subjected to carbon monoxide at corresponding temperatures. (2) The blowhole volume increases with the temperature; this is probably due to the increased solubility of gases at higher temperatures, the subsequent rate of cooling not being slow enough to allow the excess gas to escape before solidification. (3) The Brinell hardness numbers for the carbon dioxide series are higher than for the carbon monoxide experiments, with the exception of experiment No. 2, in which the greater hardness is accounted for by carburisation. This result is omitted from the hardness graph. (4) The rate of crystal growth appears to be greater with carbon monoxide than with carbon dioxide, the resulting larger grain-size accounting, in part, for the reduced hardness in the former series. (5) In general, hardness varies with the temperature, in the same sense as the blowhole volume. (6) The density determinations of blowholes were confirmed by the appearance of the specimens when cut. (7) Nitrogen produced very sound specimens. (8) An excessive volume of blowholes was found with hydrogen. (9) The addition of iron oxide in the presence of carbon monoxide increases the blowholes. Owing to the reaction,

$$CO + FeO = CO_2 + Fe,$$

it is to be expected that this addition would give results similar to those obtained in an atmosphere of carbon dioxide; this is found to be the case, and is also confirmed by the effect of the addition of oxide in the presence of coal-gas. (10) In the carbon dioxide experiments the metal round the blowholes was found to contain less carbon than the remainder, presumably due to decarburisation by the carbon dioxide during cooling, which is in agreement with the views of many previous investigators. On the other hand, with coal-gas the metal adjacent to the blowholes was carburised, probably by the hydro-carbons.

The general conclusion is reached that McCance's hypothesis is definitely confirmed by these experiments, and that whilst other factors have been shown to play a part in the formation of blow-holes under these experimental conditions, these factors, with the exception of temperature, would be relatively unimportant in steel-melting practice.

CATALOGUES.

Ball and Roller Bearings.—A further series of leaflets, with revised price lists, of roller and ball bearings is to hand from Messrs. Delco-Remy and Hyatt, Limited, 56, Victoria-street, London, S.W. 1.

Coal Conveyors.—The Coal Conveyors Company, 2, Park-grove, Cardiff, have issued a catalogue of their jigger conveyors, of the roller and chain-slung types, with electrical driving gear. The chief parts are illustrated.

Valve Sleeve.—A folder received from the Automotive Products Company, Limited, 3, Berners-street, London, W. 1, contains a description of the "Ayrtite" sleeve for shielding and lubricating the stems of automobile engine valves.

Air Heaters for Boiler Furnaces.—A temperature chart showing the effect of preheating the combustion air for boiler furnaces has been issued by Messrs. Howden Ljungström Preheaters (Land), Limited, 133, Helen-street, Govan, Glasgow.

Accumulator Charging Boards.—Five types of switch-boards, specially made for use in charging portable accumulators, are shown in an illustrated and priced catalogue received from the Electric Depôt, Limited, Pritchett-street, Aston, Birmingham.

Grinding Machines.—Messrs. Dowdings Machine Tool Company, Bush House, Aldwych, London, W.C. 2, have sent us a catalogue relating to two small surface-grinding machines for operating on surfaces 6½ in. by 18 in. and 6½ in. by 24 in., respectively.

Oil and Petrol Storage.—Tanks, pumps, building and general fittings for storing and measuring out oil and petrol are described in a catalogue issued by the Dowson and Mason Gas Plant Company, Limited, Levenshulme, Manchester. Portable tanks, fitted with measuring pumps and meters, are also dealt with.

Aluminium Repairs.—A folder showing a number of cracked or broken automobile parts made of aluminium and repaired by their process has been received from Messrs. Barimar, Limited, 14, Lambs Conduit-street, London, W.C. 1. Weak parts liable to break may also be built up in metal for reinforcement.

Saw-dust Extraction.—The James Keith and Blackman Co., Limited, 27, Farringdon-avenue, London, E.C. 4, have sent us a folder illustrating the application of their fans to the removal of saw-dust, chips and shavings from wood-working machinery. The company design and install the complete plant for this purpose.

Mechanical Stokers, &c.—A catalogue of Illinois chain-grate stokers for forced or natural draught, and also of the flat suspended arch and water back for furnaces, has been issued by the Vickers-Spearing Boiler Company, Limited, 20, Kingsway, London, W.C. 2. The illustrations and text will be found of interest as they give a clear idea of the construction, erection and operation of the plant.

Stone Preservation.—A catalogue of paints and compositions for preserving buildings has reached us from Messrs. Szerelmey, Limited, 273, Rotherhithe New-road, London, S.E. 16. The greater part of the catalogue is occupied with scientific and practical discussion of the subject of preserving buildings. The liquid used has a waterproofing effect and may be applied to stone, brick, cement, tiles, plaster, &c.

Steam Engines and Agricultural Machinery.—Messrs. Clayton and Shuttleworth, Limited, Lincoln, have sent us a loose-leaf catalogue containing illustrations and brief descriptions of their main standard products, including portable steam engines, traction engines, road rollers, oil engines, thrashing machinery, chaff cutters, &c. In each of these there is a considerable range of types and sizes to suit all the usual requirements.

Cranes and Millwork.—We have received a copy of an interesting book containing some fifty illustrations of the works and products of Messrs. Kampnagel, of Hamburg, prefaced by a history of the firm. Founded sixty years ago as Nagel and Kaemp, the firm has consistently specialised in harbour and railway crane equipment, machinery for milling grain and plant for manufacturing Portland cement. The text is in English and will be read with interest by British engineers at the present time.

Valves.—Messrs. Hunt and Mitton, Limited, Oozells-street North, Birmingham, have issued their sectional catalogues complete in a bound volume, which will be useful for reference as one of the most comprehensive of its kind. The six sections refer to: steam, hydraulic, and chemical valves and fittings; pressure and vacuum gauges and fittings; lubricators; boiler mountings of all kinds and for all pressures; relief valves in bronze, iron and steel and reducing valves; and fire-extinguishing appliances. Each section deals with all the types in general use, and covers most requirements for valves and fittings for high pressures and superheated steam.

P. AND O. LINER "COMORIN."—The twin-screw mail and passenger steamer Comorin, built for the Australian service of the Peninsular and Oriental Steam Navigation Company by Messrs. Barclay Curle and Co., Limited, recently completed successful trials on the river Clyde, when a mean speed of 17½ knots was attained. This vessel is 545 ft. in length, 70 ft. in breadth, and 46 ft. in depth, and has a gross tonnage of 15,000. A dead-weight of 11,000 tons can be carried, and half of the 600,000 cubic ft. of cargo space available is cooled by means of refrigerating machinery and insulated for the transport of perishable materials and produce. Three decks are devoted to the accommodation of the two hundred first and one hundred second-class passengers carried. Cabins are of the single and two-berth types only, the number of the former being twice that of the latter. The propelling machinery consists of balanced twin-screw quadruple expansion engines. Steam is supplied by seven boilers working at a pressure of 220 lb. per square inch and burning oil under forced draught. Amongst the subsidiary features are included mechanical operation of the watertight doors and ventilation, and very ample provision of lifeboats.